6-1974

Environmental Study of a Portion of the Middle Ordovician in Sequatchie Valley, Eastern Tennessee

Ernest Wilson Blythe Jr.
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by Ernest Wilson Blythe Jr. entitled "Environmental Study of a Portion of the Middle Ordovician in Sequatchie Valley, Eastern Tennessee." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Geology.

Kenneth R. Walker, Major Professor

We have read this dissertation and recommend its acceptance:

Harry Klepser, Robert E. McLaughin, Robert G. Long

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

June, 1974

To the Graduate Council:

I am submitting herewith a dissertation written by Ernest Wilson Blythe, Jr., entitled "Environmental Study of a Portion of the Middle Ordovician in Sequatchie Valley, Eastern Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Geology.

Kenneth L. Walker
Major Professor

We have read this dissertation
and recommend its acceptance:

Harry J Klepser

C. E. McLaughlin

Robert G. Long

Accepted for the Council:

Hilton A. Smith
Vice Chancellor for
Graduate Studies and Research

ENVIRONMENTAL STUDY OF A PORTION OF THE MIDDLE ORDOVICIAN IN SEQUATCHIE VALLEY, EASTERN TENNESSEE

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee

Ernest Wilson Blythe, Jr.

June 1974

ACKNOWLEDGMENTS

I wish to express appreciation to Dr. Kenneth R. Walker who suggested the study, advised throughout, answered many of the enigmas posed by carbonate rocks for me and supplied financial aid for part of the expense of reproducing photographs (from a National Science Foundation Research Grant).

Appreciation in also given to Drs. Harry J. Klepser, Robert E. McLaughin of the Geology Department and Robert G. Long of the Geography Department who reviewed this report and offered many helpful suggestions. I would also like to thank Robert C. Milici of the Tennessee Division of Geology who led me to outcrops and provided unpublished field maps of Sequatchie Valley.

I should like to remember Dr. George D. Swingle, now deceased, who was my advisor in preparation for this dissertation. He was gentle and unpretentions. He had a brilliant geological mind with a knowledge of the geology of East Tennessee that was unsurpassed. I am deeply sorry for the loss of my teacher and friend.

I am grateful for the support in the form of financial aid from the Geological Society of America (Penrose Bequest Research Grant), the Society of the Sigma XI (grant-in-aid of research), The University of Tennessee-Martin, and The National Science Foundation. I am also grateful for Harry Moore's help in preparation of samples.

I wish to express gratitude to my wife Evelyn for contributing in enumerable ways toward the completion of this work.

I wish also to thank my colleagues at the University of Tennessee -Martin, especially W. T. McCutchen and K. V. Bordeau for the opportunity for time away from teaching that allowed me to finish this report.

ABSTRACT

A detailed depositional environmental analysis of a portion of Middle Ordovician Carters Limestone and Hermitage Formation in Sequatchie Valley in East Tennessee was made using six stratigraphic sections as closely spaced as permitted by reasonably complete outcrops. The approximately 60 feet of rocks of this stratigraphic interval include 18 distinct lithologies as determined from a field study and examination of samples collected at one foot intervals and closer with changes in lithology. Two bentonite beds generally accepted as being isochronous units offer a time framework. In all 565 samples were collected and of these 447 were cut, polished, and an acetate peel made from the acid-etched surface. Two hundred and forty-four 2X3 inch thin-sections were also prepared. The peels and thin-sections were the basis for a petrographic study with point counts of selected thin-sections.

The investigation disclosed a sequence of environmental changes for the area of study beginning with subtidal conditions and an abundant carbonate generating fauna. This was followed by a tidal flat environment with mudbanks and supratidal islands. The next environment of deposition was another subtidal episode. These environments, an apparent regressive-transgressive sequence, fit into the carbonate bank portion of the model for Middle Ordovician strata proposed by Walker and Alberstadt (1973).

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

FIGURE PAGE

FIGURE PAGE

FIGURE PAGE

CHAPTER I

INTRODUCTION

General

Studies involving Middle Ordovician carbonates of the Southern Appalachians customarily have been approached from the standpoint of gross stratigraphy and mappability. Recently, however, several researchers have made depositional environmental analyses in Central Tennessee (Alberstadt, 1973) and in East Tennessee (Walker and Ferrigno, 1973; Ferrigno,1973; Stephenson, Walker, and Moore, 1973; Stephensen, Walker, and McLaughlin; Milici and Walker, 1973; and Ratliff,1974) which have led to a better understanding of Middle Ordovician strata (see for example Walker, 1974).

Exposures of Middle Ordovician rocks in East Tennessee's Sequatchie Valley furnish a favorable setting for detailed investigation of depositional environments of carbonate strata. The setting is favorable because the interval of interest is almost entirely exposed in several locations, and the outcrop pattern around the nose of the northeast plunging Sequatchie anticline provides a three dimensional view of the rocks.

Purpose of the Study

The purpose of this study is to investigate in detail, the rocks in the stratigrahic vicinity of two prominent Middle Ordovician

"bentonites" (presumptive volcanic-ash beds) in an attempt to observe the subtle environmental changes that occur in carbonate rocks which have lithologies that are superficially quite similar. These two "bentonites" are generally accepted as being isochronous units. In this report they are used as a time framework, in order to provide a detailed lithofacies array in space and time.

Comparison of sediments in Recent carbonate sedimentological environments with the Middle Ordovician carbonates of this study, reveal that the Middle Ordovician physical environments are analogous to certain Recent carbonate environments.

This study should contribute information useful to stratigraphers interested in regional correlation of Ordovician carbonates between the Central Basin, Sequatchie Valley, and Valley and Ridge portions of Tennessee and between strike belts in the Valley and Ridge. Work already done in these areas will be referred to in other parts of this report. This study should also provide a physical environmental framework within which paleoecological analysis of some Middle Ordovician fossil assemblages can be achieved.

Location and Extent of the Study Area

Sequatchie Valley, and the six exposures of Middle Ordovician strata upon which this report is based, are located within the Cumberland Plateau physiographic province in eastern Tennessee (Fenneman, 1938).

The valley is the result of erosion of a faulted anticline formed near the end of the Paleozoic Era. It averages about 5 miles in

width and is some 150 miles in length, trending southwestward from Tennessee into Alabama where it is known as Browns Valley.

The study area is in the northeastern portion of Sequatchie Valley where the Sequatchie anticline plunges to the northeast. The Middle Ordovician strata are exposed where they wrap around the nose of the anticline (Figure 1) before being faulted out on the northwest side of the valley. The strike of the outcrop belt along the southeast side of the valley trends northeast to southwest the beds dipping to the southeast from about 10 to 35 degrees.

The Litton section is located on the northwestern limb of the Sequatchie anticline. The Burke section is located on the northwest side of the nose of this anticline. The Pee Dee Ridge, Mill Branch, Howard Cemetery and McWilliams Creek sections are located on the southeast limb of the anticline in order from northeast to southwest. See Figure 1 and Table I for the locations of these sections.

Previous Studies in the Area

It has long been recognized that Middle Ordovician strata exposed in Sequatchie Valley are strategically located between exposures of the Central Basin and those of the Valley and Ridge in East Tennessee. The stratigraphy of Sequatchie Valley was first described by Hayes (1895) in his Pikeville Folio, Tennessee. The rocks included in the stratigraphic interval of the present study were called Chickamauga Limestone. The same name was used in his earlier work (Hayes, 1894) for exposures in the valley of West Chickamauga Creek in Hamilton County, Tennessee and Catoosa and Walker Counties in Georgia.

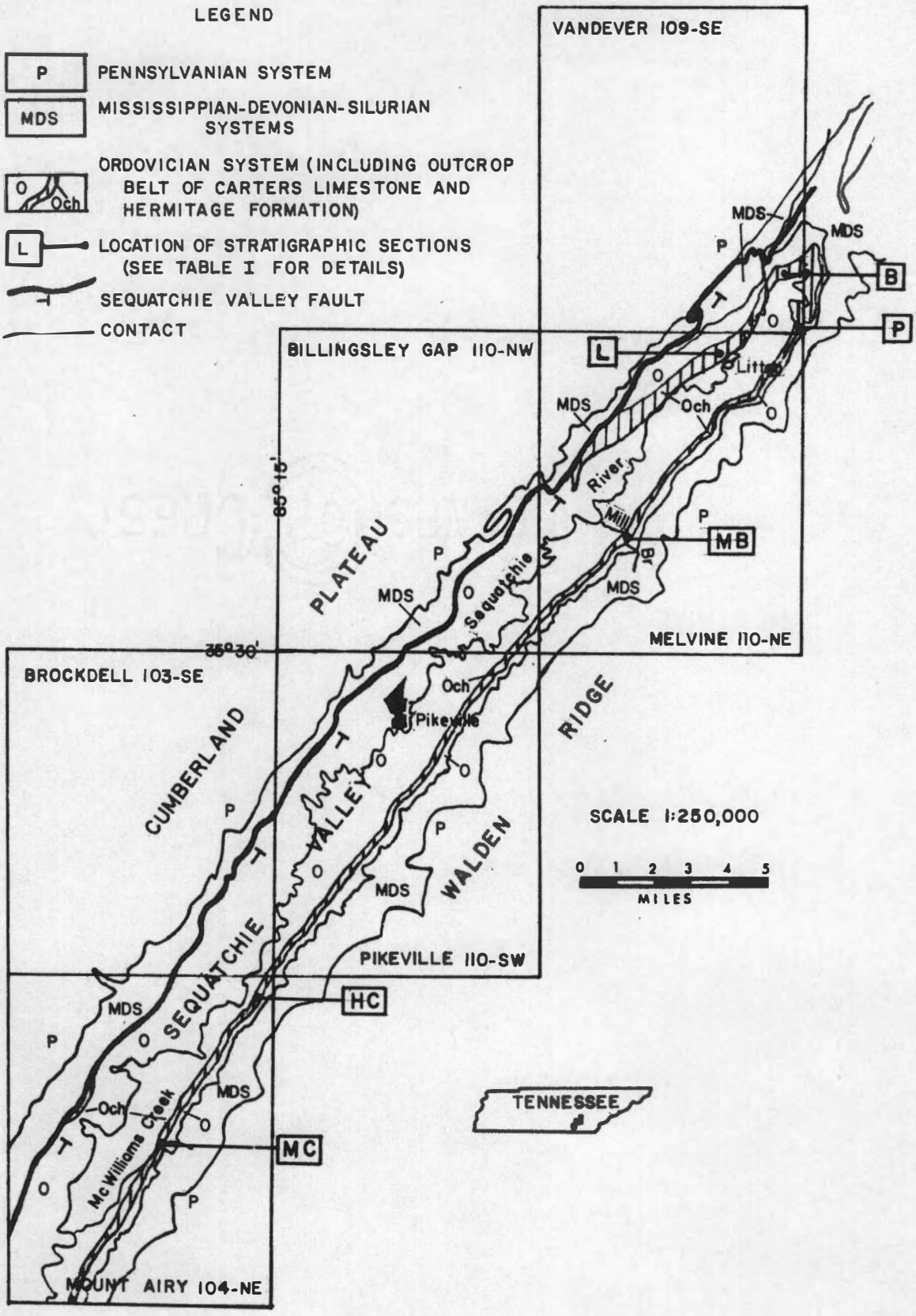

Figure 1. Map locating the area of study.

TABLE I

LOCATION OF STRATIGRAPHIC SECTIONS

Section		Location			
Name	Sumbol	Quadrangle	Tennessee Coordinates		
Burke	B-	Vandever (7 1/2') 109-SE	Base[a]	504,560N.,	2,292,200E.
			Top	504,400N.,	2,292,350E.
Pee Dee Ridge	P-	Vandever (7 1/2') 109-SE	Base	497,000N.,	2,296,350E.
			Top	496,800N.,	2,296,700E.
Litton	L-	Melvine (7 1/2') 110-NE	Base	492,850N.,	2,284,180E.
			Top	493,380N.,	2,284,100E.
Mill Branch	MB-	Melvine (7 1/2') 110-NE	Base	467,800N.,	2,271,500E.
			Top	466,900N.,	2,272,100E.
Howard Cemetery	HC-	Mount Airy (7 1/2') 104-NE	Base	399,000N.,	2,219,500E.
			Top	398,700N.,	2,219,700E.
McWilliams Creek	MC-	Mount Airy (7 1/2') 104-NE	Base	380,100N.,	2,207,850E.
			Top	380,175N.,	2,208,050E.

[a]Basal Portion below T-3 Bentonite in field beginning at Tennessee Coordinate 504,400N., 2,292,550E. to 504,500N., 2,292,650E.

Bassler (1932) compiled a general stratigraphic section in Sequatchie Valley from notes furnished him by E. O. Ulrich and Charles Butts. Wilson (1949) includes a composite stratigrahic section of pre-Chattanooga rocks measured at eight locations in Sequatchie Valley. The location of one of the sections, given to him by Butts and Bassler, corresponds closely with the Litton section of the present study.

The most recent work on the straigraphy of Sequatchie Valley has been done principally by Robert C. Milici in a series of maps and articles mentioned in various parts of this report. Milici (1970) summarized the development of stratigraphic nomenclatue for Middle Ordovician strata in Sequatchie Valley. Milici and Smith (1969) described the evolution of nomenclature for Ordovician strata in Tennessee and Northwestern Georgia. Table II, modified from these two studies, summarizes the nomenclatural history of the interval.

Present Study

The present study goes into greater detail than previous studies of Middle Ordovician strata in this area. Other workers have been concerned with delineation of mappable units, whereas, this study was concerned with a stratigraphic framework that required close lithologic examination in order to resolve depositional environments.

The original plan was to study stratigraphic sections about one to two miles apart so as to obtain maximum stratigraphic control, but this was only possible in the three sections near the northeast end of the valley. The other three sections were spaced as closely

TABLE II

MIDDLE ORDOVICIAN STRATIGRAPHIC NOMENCLATURE IN SEQUATCHIE VALLEY, TENNESSEE[a]

Hayes (1895)	Butts (Unpublished Map)	Bassler (1932)		Wilson (1949)		Swingle (1964)	Milici (1970)			Interval Covered by This Report
Chickamauga Limestone	Catheys Limestone	Catheys Formation		Nashville Group	Catheys Formation	Chickamauga Group	Chickamauga Supergroup	Nashville Group	Catheys Formation	
	Flannagan Limestone	Cannon Limestone			Cannon Facies of The Bigby Cannon Limestone				Cannon Limestone	
	Curdsville Limestone	Hermitage and Curdsville Limestone			Hermitage Formation				Hermitage Formation	Hermitage Formation
	Lowville Limestone	Lowville Limestone		Stones River Group	Carters Limestone			Stones River Group	Carters Limestone	Upper and Lower Members of the Carters Limestone
	Lebanon Limestone	Stone River Group	Lebanon Limestone		Lebanon Limestone				Lebanon Limestone	
	Ridley Limestone		Ridley Limestone		Ridley Limestone				Ridley Limestone	
					Pierce Limestone					
	Mosheim Limestone		Murfreesboro Limestone		Murfreesboro Limestone				Murfreesboro Limestone	
									Pond Spring Formation	

[a]Modified after Milici (1970)

as reasonably complete outcrops would allow. The minimum spacing between outcropping sections (Burke-Peedee Ridge) is 1 mile, and the maximum (Mill Branch-Howard Cemetery) is 12 miles. The sections were described in the field and these descriptions, revised by reference to samples, are included in Appendix A of this report.

The field descriptions were used to separate the six sections into eighteen lithologic types, forming a stratigraphic framework for detailed macro-and micro-petrographic study of samples.

Methods

The field descriptions were compiled from an inch by inch inspection of the rocks. Samples were taken at each one foot interval and at lesser intervals where changes in lithology occurred. A total of 565 samples were gathered during the field study. Of these 447 were of sufficient size, and coherent enough in lithology, to cut and polish. Most of the polished samples, with an average size of approximately 3" x 4", were acid-etched and the surface subsequently used in the preparation of acetate peels. Parts of samples from the three sections which are virtually one hundred percent exposed were used to prepare 244, 2" x 3" thin sections.

To determine the amount and nature of dolomite, about one fourth of each thin section was stained following the method described by Sabins (1962) using a dilute HCl solution with alizarin red-S dye.

All polished slabs, acetate peels, and thin-sections were examined. One hundred-fifty slabs and their acetate peels were chosen

for detailed petrographic analysis. Sixty thin-sections were selected for detailed petrographic analysis. Composition analyses compiled from point count of selected thin-sections during these analyses are summarized in Appendix B. Petrographic descriptions in Appendix B follow the classification of Folk (1959, 1962, 1965).

Selected samples of lithologies suspected of containing appreciable amounts of clay minerals were tested for acid insoluble residues. They were placed in hydrochloric acid for a time sufficient to achieve separation of non-carbonate from carbonate components. Samples of lithologies tested were found to have acid insoluble residue volumes ranging from approximately 20 to just over 50 percent. The lithologies found containing these percentages of insolubles will hereafter be referred to as argillaceous limestone, very argillaceous limestone, or calcareous mudstone.

CHAPTER II

STRATIGRAPHIC FRAMEWORK

General

It is necessary to have as complete an understanding as possible of rock-stratigraphic and time-stratigraphic relationships in a sequence of strata, in order to make inferences relative to depositional environment. Due to the lack of descriptions of strata in the study area detailed enough for environmental analysis, the writer's first concern was to make a detailed field investigation and measurement of the six stratigraphic sections chosen for their completeness of exposure.

The field investigation was accomplished during the period between November 1968 to July 1969.

Stratigraphy of the Region

The present study is of local rather than regional scope. Consequently, previous investigations will be relied upon for the regional rock- and time-stratigraphic relationships. These investigations are summarized here only briefly.

That the strata involved in this study are of Middle Ordovician age is well established in the literature by workers such as Bassler (1932), Wilson (1949) and Milici (1970). Milici and Smith (1969) proposed a new rock classification for Middle Ordovician strata at the type locality. This included elevation to supergroup status for the

Chickamauga Group (Swingle, 1964) allowing for the use of Wilson's (1949) Stones River Group and overlying Nashville Group (see Table II, page 8). Milici (1970) correlated Chickamauga Supergroup strata at the type locality east of Chattanooga with Sequatchie Valley strata.

Portions of two formations the Carters Limestone of the Stones River Group and the Hermitage Formation of the Nashville Group, were studied in detail for this report.

Carters Limestone

The Carters Limestone, shortened from Safford's Carters Creek Limestone by Hayes and Ulrich (1903) has been separated into two members by Milici (1970) in the study area. The Carters was first divided into the Upper and Lower Members in Central Tennessee by Wilson (1938). The two members are separated by the T-3 bentonite and the underlying chert. A discussion of the bentonites of this sequence follows on page 12.

Lower Member

Milici (1970) described this member as being:

> ...composed of 70 to 140 feet of fucoidal, medium light- to medium-gray limestone generally in beds 1- to 2-feet thick. Partings of thin beds of argillaceous limestone are common and some beds contain dark gray chert in irregular layers 2 or 3-inches thick. Weathered limestone is medium-light to light gray and cherts weather yellowish brown.

The present study concerns only the top 15 to 20 feet of this member.

Upper Member

Milici (1970) described the upper member of the Carters Limestone of the region as follows:

> ...composed of medium-gray argillaceous calcilutite or calcisiltite, generally in beds 1- to 6- inches thick. The light olive-gray or yellowish-gray color is characteristic of the weathered limestones. The member is generally unfossiliferous, although fossils are common in the chert below the T-3 bentonite. Some beds are shaly, some laminated, some mud cracked, and some contain thin beds of intraclasts

T-3 and T-4 Bentonites

Wilson (1938), in order to "facilitate" reference to bentonite beds observed in the Carters Limestone, designated them from the lowermost to uppermost T-1, T-2, T-3 and T-4, the "T" representing Tennessee. Fox and Grant (1944) correlated Ordovician bentonites in Eastern Tennessee, Sequatchie Valley, and Central Basin of Tennessee. They designated the bentonite beds differently without referring to Wilson's earlier work. This report uses Wilson's designations for reason of earlier publishing date and their wide use in subsequent Tennessee Division of Geology maps and reports.

In the region of this report, the T-4 bentonite and underlying chert occur nine to thirteen feet below the top of the Carters Limestone according to Milici (1970). He also reported that the T-4 chert is generally thinner than T-3 chert and assumed the reason for this to be that the T-3 bentonite is thicker than the T-4 bentonite. He infers a thickness of three feet and two feet respectively for T-3 and T-4 bentonites.

Hermitage Formation

The Hermitage Formation, named by Hayes and Ulrich (1903) for exposures near Hermitage Station, Davidson County, is the lowest formation of the Nashville Group. Wilson (1949) placed "what is undoubtedly an erosional unconformity" between the Carters and Hermitage. This may be true in the Central Basin, but evidence for unconformity in Sequatchie Valley is lacking as pointed out in the discussion to follow.

Milici (1970) described the Hermitage of the region as:

> ...composed of 60 to 70 feet of argillaceous medium-gray to medium dark gray or light olive gray calcilutite to calcarenites. The beds are 6 inches to 2 feet thick and commonly weather to a rubble of irregular limestone nodules. Silicified brachiopods, cup corals and gastropods are common.

Outcrops of Hermitage are sparse, and in most locations outcrops of only the lower ten to fifteen feet of the formation are exposed. For this reason the present report includes only the lower ten to fifteen feet of the Hermitage.

Time-Stratigraphic Relationships in the Region

Time-stratigraphic nomenclature has not been satisfactorily defined for subdivisions of the Middle Ordovician System in Central and Eastern Tennessee. Bassler (1932), Wilson (1949), Milici and Smith (1969), and Milici (1970) have correlated rock-stratigraphic units of the region but have not completely correlated the time-stratigraphic units.

It is beyond the scope of this report to correlate regional time-stratigraphic units; however, the writer feels that evidence from the detailed investigations in this restricted area (discussed in subsequent chapters), shows that some lithologic units are time transgressive. Therefore, the contacts chosen for formational boundaries do not necessarily coincide with synchronous surfaces. More detailed investigations such as this will be necessary in order to ultimately work out time-stratigraphy of the region with any degree of confidence. Twenhofel et al. (1954) placed the Carters Limestone and Hermitage Formation of the Central Basin of Tennessee in the Trentonian Substage of the Mohawkian Stage of the Champlainian Series. Cooper (1956, Chart I, facing page 130), placed the Carters Limestone of the Sequatchie Valley in his Wilderness Stage and the Curdsville Limestone (the lower part of the Hermitage Formation of current usage) in the Trenton stage. Fisher's (1962) reorganization of time-stratigraphic nomenclature for the traditional standard sections in New York State placed the Wilderness Stage of Cooper (1956) and the Barneveld Stage, which he substitutes for Cooper's Trenton Stage into the Mohawkian Series. Fisher preferred to leave the name Trenton for rock-stratigraphic use. The Mohawkian Series was correlated by Fisher (1962) as a portion of the Caradoc Series of the type section of the Ordovician System in the North and South Wales area of Great Britain. McLaughlin (1973) reviews the difficulties in attempts to correlate with the North American reference standards for rocks of Ordovician age in Knox County, Tennessee and vicinity. For the purpose of the present study, the presence of

presumably time-parallel bentonite units yields a satisfactory local time-stratigraphic framework within which the analysis could be accomplished.

Detailed Rock-Stratigraphic Framework

Analysis of field descriptions (Appendix A) and 565 samples reveals that the measured sections contain 18 lithologically distinct types. Table III provides a description of each of the lithologic types. Not all of the 18 lithologic types appear in every measured section. The reader should refer to Figure 2 and the descriptions in Table III for correlation and distribution of lithologic types within the six measured sections. The T-4 bentonite has been selected as datum for the sections in Figure 2 and the chert (lithology 12) that underlies the T-4 and T-3 bentonites (lithology 13) is shown as heavy lines the thickness of the cherts connecting all the sections. Lithologies 10A and 10B which differ mostly is size of grains are grouped as lithology 10 in Figure 2 because the distribution of the 2 variants seem to be random in the same interval. Some thin intraclastic zones (lithology 4) are shown connecting between several sections. It is possible that these layers are not continuous but are separate occurrences of lithology 4 in close to the same stratigraphic position.

TABLE III

LITHOLOGIES WHICH MAKE UP THE INTERVAL OF STUDY[a]

Lithology	Description
1	Limestone, very fine-grained, dark to dusky yellowish brown (10YR4/2 to 10YR2/2) thin to massively bedded, with fine grained pale yellowish brown (10YR6/2) and darker horizontal burrow mottling. Fragmentary fossils concentrated in layers and lenses also scattered in the matrix. Articulated and disarticulated brachiopods; crinoid or cystoid and trilobite debris; bryozoans; and rugose corals. Tabulate coral colonies in life position present. Chert, mostly olive black, (5Y2/1) in layers and nodules.
2	Limestone, coarse grained, fossils and fossil debris of brachiopods, pelecypods and ostracods, many filled with sparry calcite. Also gastropods and trilobite debris. Olive gray to light olive gray (5Y4/1 to 5Y6/1), fine to very fine grained matrix. Abundant clear and white sparry calcite. Occasional intraclasts.
3	Limestone, laminated with "birdseyes", olive gray to brownish gray (5Y4/1 to 5YR4/1), very fine grained, with occasional one inch to two inch lenses of fossil debris. Abundant mudcracks mostly filled with clear sparry calcite. Calcite also between laminae.
4	Limestone, intraclastic, with occasional fossil fragments in a fine to very fine grained matrix. The intraclasts vary in size from a few millimeters to several centimeters, are subangular to rounded, and fine to very fine grained. Color mostly olive gray to light olive gray (5Y4/1 to 5Y6/1).
5	Limestone, argillaceous and dolomitic, laminae of light olive gray to yellowish gray (5Y6/1 to 5Y8/1) fine to very fine grained. Alternating with olive gray (5Y4/1) limestone which is characterized by interlaminar sparry calcite birdseyes one to two millimeters thick. Lamination is characteristic, mudcracks are common. Intraclasts and fossils are rare.

TABLE III (continued)

Lithology	Description
6	Limestone, argillaceous and dolomitic, light olive gray (5Y6/1), irregularly laminated, very fine grained, with an abundance of birdseyes.
7	Limestone, argillaceous grayish olive (10Y4/2), very fine grained and laminated, with lenses and laminae of fossil debris and interlaminar calcite 1-2mm diameter. Olive gray (5Y4/1) fossil fragments are possibly trilobite, ostracods, and brachiopods. Wide mudcracks common with large polygons three or four inches across. Cracks generally filled with overlying lithology. Some small scale cross-lamination.
8	Limestone, argillaceous, very fine grained, olive gray to brownish gray (5Y4/1 to 5Y4/1) which is mottled greenish gray (5GY6/1). Mottling possibly represents vertical burrows with at least one U-shaped burrow. Some of the burrows are partially filled with clear calcite. The foregoing serves as matrix for an abundance of coarse Tetradium sp. debris and Tetradium sp. in life position. The coralites are filled with very fine grained matrix and sparry calcite. Occasional brachiopods.
9	Limestone, very fine grained, olive gray to dark greenish gray (5Y4/11 to 5GY4/1) with light olive gray (5Y6/1) horizontal mottling. Fossils scattered in patches and isolated. Occasional mudcracks and ripple marks. Bedding is mostly irregular and thin to medium, some laminae. Trilobite debris, silicified bryozoans, also articulated brachiopods which are mostly filled with very fine grained matrix but occasionally with sparry calcite (about same lithology as 8 minus the Tetradium).
10(A)	Limestone, olive black (5Y2/1), coarse grained, fetid, thin to massive bedded, characterized by large white and pink sparry calcite filled brachiopods and bryozoans which are the major constituents in some beds. A wide range of size in the coarse fraction, from about one millimeter to three or four centimeters. Articulated brachiopods and voids partially filled with crystalline

TABLE III (continued)

Lithology	Description
	calcite. Other fossils include orthoconic cephalopods, rugose corals, pelmatozoan, and trilobite debris. The matrix is sparry calcite, generally a lighter color than the whole rock. Also some fine to very fine grained material.
10(B)	Limestone olive black to rarely olive gray (5Y2/1 to 5Y4/1), mostly fine to very fine grained, fetid, with coarse fossil debris a few millimeters across. (About the same as 10A but fine matrix more abundant).
11	Limestone, dark and pale yellowish brown (10YR4/2 and 10YR6/2), fine to coarse grained fossil debris with white to clear sparry calcite cement.
12	Chert, olive black to brownish black (5Y2/1 to 5YR2/1) replacing and invading limestone beneath bentonite beds.
13	Bentonite, pale bluegreen (5BG7/2) clay (T-3 and T-4).
14	Limestone fine grained to very fine grained, cross laminated olive gray to olive black (5Y4/1 to 5Y2/1). Coarse grains common as fossils and fossil debris including Tetradium debris, brachiopods, bryozoans, calcite filled orthoconic cephalopods.
15	Limestone, very argillaceous or calcareous mudstone, dolomitic and laminated. Light olive gray to yellowish gray (5Y6/1 to 5Y8/1), very fine grained with large mudcracks (1-1/2 to 2 inch polygons) with as much as 1/4 inch separation. Weathers yellowish gray to grayish yellow (5Y7/2 to 5Y8/4) and the polygons become rounded toward the cracks
16	Calcareous mudstone or very argillaceous limestone. Dark greenish gray to grayish olive (5GY4/1 to 10Y4/2), very fine grained, laminated with some interlaminar calcite patches. Mudcracked, weather yellowish gray (5Y7/2) with dusky yellowish brown stains.

TABLE III (continued)

Lithology	Description
17	Calcareous mudstone, dark greenish gray to greenish gray (5GY4/1 to 5GY6/1) with grayish red purple (5RP4/2), some lamination, and mudcracked with 1/2 inch to 1 inch polygons. Possibly vertical burrow mottling.

[a]See Appendix A for grain-size, bedding, color, etc., conventions.

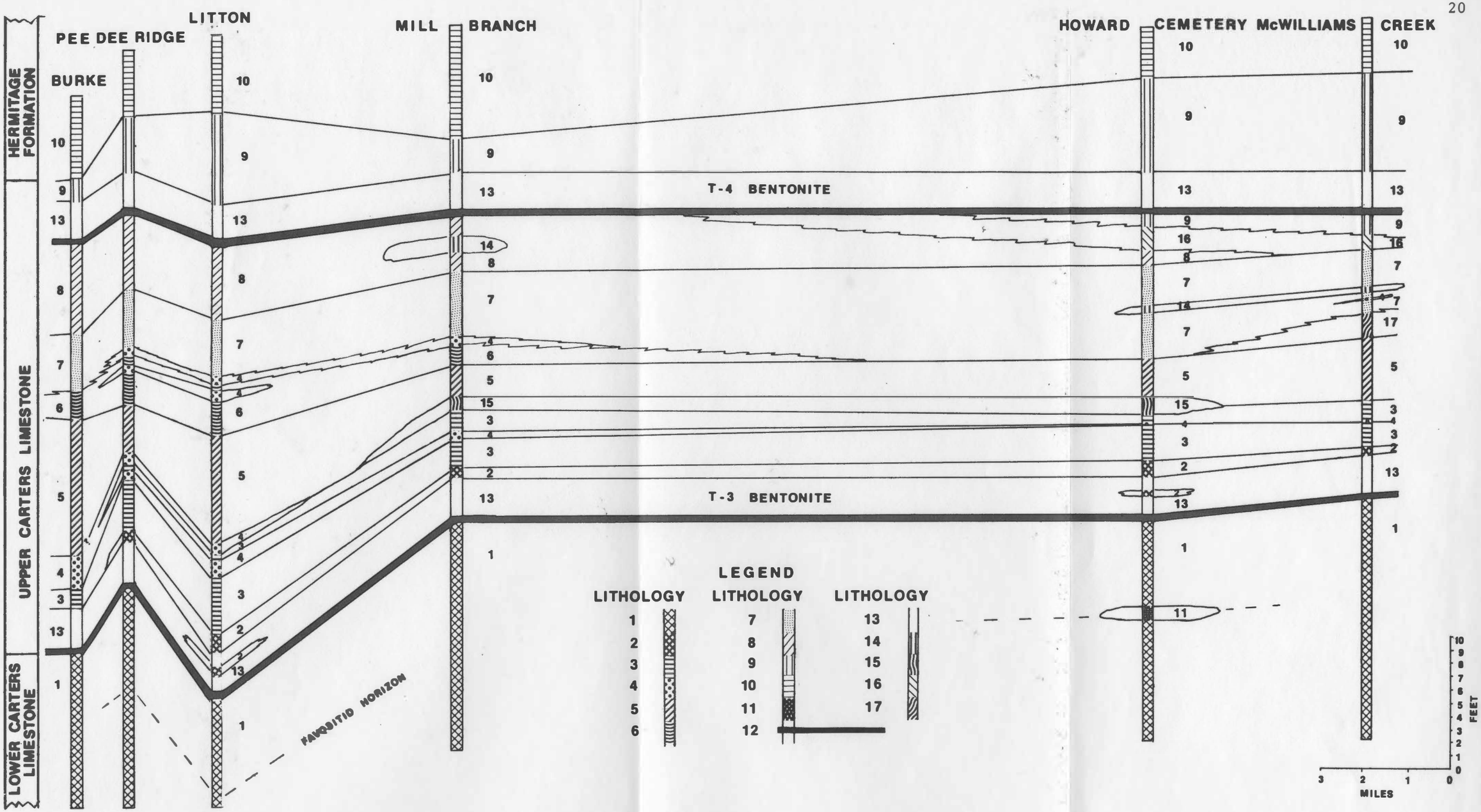

Figure 2. Fence diagram of Rock-Stratigraphic distribution of Lithologies 1 through 17 for the six stratigraphic sections of this report. Refer to Table III for lithologic descriptions. Lithology 12 (chert) beneath T-4 Bentonite is datum.

CHAPTER III

DEPOSITIONAL ENVIRONMENTS BASED ON SEDIMENTOLOGICAL EVIDENCE

General

Identification of lithologies 1 to 17 described in the previous chapter provide the basis for drawing inferences concerning the depositional environments of the Carters and Hermitage in the study area.

Assignment of depositional environments made in the following pages is based on information obtained from the microscopic analyses of peels and thin-sections, field observations summarized in Chapter II, and measured sections which comprise Appendix A.

Appendix B contains summaries of constituent particle analyses resulting from counting 500 points on each of 60 thin-sections. The thin-sections were chosen as best representing Lithologies 1 through 17. Negative prints and photographs of some of the acetate peels and samples that illustrate features indicative of the depositional environments particularly well are shown in this chapter.

All the lithologies (1-17 of Table III) are believed to have sedimentallogical differences related to the environment in which they were deposited. Some of the lithologies have gross differences but others have close similarities. Yet, even those with similar lithologies have environmentally significant differences.

The principal environments of deposition displayed by the lithologies in the study area are those which occur near shore and are for the most part associated with shallow marine waters. The terms subtidal, intertidal, and supratidal are used in descriptions of the environments. Definitions of these terms are those suggested by Laporte (1967, p. 82, p. 85) as follows:

> Subtidal: that zone which is nearly always covered by marine water
>
> Intertidal: that strand zone which is regularly and periodically flooded by marine water at unspecified intervals and for unspecified duration.
>
> Supratidal: that strand zone only rarely flooded by marine water, but with a distinct marine influence.

The depositional environment assigned to the lithologies summarized in Table III page 16 are shown in Table IV. Numbers 1 through 10 represent lithologies that have wide distribution in the study area and are volumetrically more abundant than lithologies 11, 14, 15, 16, and 17. Some of the latter group are considered subunits of the former group and are so designated in Table IV.

Table V (modified after Laporte, 1971) lists lithologic and paleontologic characteristics of nearshore environments of deposition. These characteristics are compared with the results of the present study in the following paragraphs.

TABLE IV

DEPOSITIONAL ENVIRONMENTAL ASSIGNMENTS FOR LITHOLOGIES IN THE STUDY AREA

Lithology	Depositional Environment	Associated Principal Environment
1	Subtidal - quiet water biomicrite and tidal channel intraclastic biosparite.	
2	Shallow subtidal - biopelsparite	
3	Low intertidal - tidal flat	
4	Intraclastic zones within several lithologies	(3,5,6)
5	Highintertidal-supratidal.	
6	Supratidal	
7	Intertidal - tidal flat	
8	Subtidal - Tetradium biostrome and margin	
9	Shallow subtidal - low intertidal	
10	Shallow subtidal - biosparite	
11	Subtidal - tidal channel biosparite	(1)
12	Chert - post depositional alteration of volcanic ash to bentonite	(1,8,9)
13	Volcanic Ash - altered to bentonite and reworked bentonite	(2,9)
14	Tidal channel (possibly tidal delta)	(7,8)
15	Supratidal - dolomite crust	(3,5)
16	Intertidal - argillaceous micrite	
17	Supratidal - argillaceous micrite	

TABLE V

LITHOLOGIC AND PALEONTOLOGIC, CHARACTERISTICS OF NEAR SHORE ENVIRONMENTS OF DEPOSITION (MODIFIED AFTER LAPORTE 1971 p. 728) TABLE OF CAMBRIAN THROUGH DEVONIAN CARBONATES IN THE CENTRAL APPALACHIANS)

Characteristic		Environment of Deposition				Main Reference Source
		Supratidal	Intertidal	Shallow Subtidal	Deep Subtidal	
Lithologic	Mud cracks	large polygons		--	--	Ginsburg (1957)
	Birdseye	very abundant	abundant	--	--	Shinn (1968)
	Scour and Fill		common	common	--	Ball and others (1967)
	Intraclastic Zones	common	common	rare	--	Ginsburg (1957)
	Laminations	wavy thin abundant	common	--	--	Ginsburg et al. (1954)
	Early Dolomite	common	common	--	--	Pray and Murry, 1965
	Cross-stratification	common	small scale	medium scale		--
	Burrow-Mottling	rare	rare	common	abundant	Walker (1969)
	Oolites	--	--	often present	--	Ball (1967)
	Bedding	thin	thin	medium thick	thick/ massive	--
	Sparite/Micrite	variable	variable	high-low	low	--
Paleontologic	Algal Structures	stromatolites	stroma-tolites	oncolites	--	Logan et al. (1964)
	Burrows	rare	vertical	vertical/ horizontal	horizontal	Rhoads, 1967
	Fossil Abundance	low	low	very high	variable	Laporte, 1968
	Fossil Diversity	low	low	medium	usually high	Laporte, 1968

Analyses and Interpretations of Lithologies Present in the Study Area

Analysis of Lithologies 1 and 11

Lithology 1 is composed of two lithic types as confirmed by thin-section analysis of selected samples. Constitutent particle analyses of selected thin-sectioned samples are summarized in Appendix B. The dominant lithic type which constitutes an estimated 90 percent of the lithology is a mottled biomicrite. The remaining 10 percent is an intraclastic biospartie. The two lithic types are interbedded with the occurrence for biosparite increasing in frequency near the top of the interval. Figure 3 is a photograph of the typical appearence of Lithology 1.

The mottled biomicrite is distinguished by the predominance of horizontal mottling and by the amounts and kinds of fossils in the micrite. Figure 4 and Figure 5A, show typical mottling as irregular bands that pinch and swell from less than 1 millimeter to a centimeter or more when exposed longitudinally either by weathering or by the cut of the rock saw. Transverse sections appear as rounded to ovoid "holes" or mottles. Bifurcation of the mottling is common. Figure 6 shows mottling which consists primarily of euhedral dolomite rhombs approximately 120 microns and less across. In some of the mottles pellets are observed to grade into dolomite rhombs. A thin-section was treated with potassium ferrocyanide resulting in a blue stain on minerals containing iron. Upon inspection of mottling after staining,

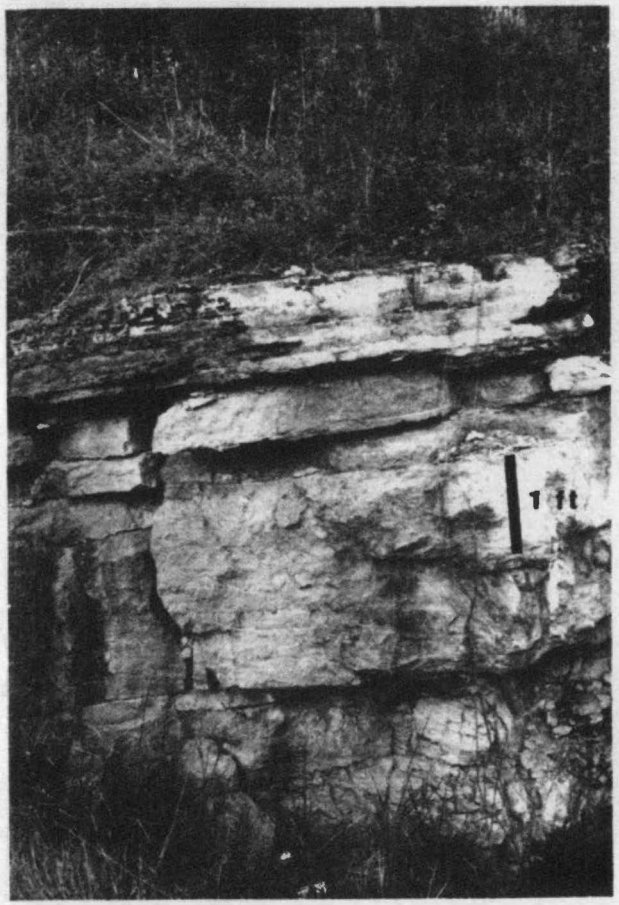

Figure 3. Photograph of outcrop appearence of Lithology 1 at the litton section. The biosparite lithic type increases in frequency in the massive bed in the center of the outcrop.

Figure 4. Photograph of typical weathering of mottled biomicrite. Handlens at the left is 4 cm long. Note ovoid to circular "holes". The dark nodular layer in the center is chert.

Figure 5

Lithology 1

A. Negative print (actual size) of an acetate peel of sample L-3. Horizontal mottling typical of biomicrite lithic type. Also notice the rounded to ovoid isolated mottles. The arrow shows the vertical.

B. Negative print (actual size) of an acetate peel of sample L-9. Note concentration of fossil debris in micrite matrix. Longitudinal and transverse sections of crinoid columnals can be seen in the center of the peel. Dark area at the top is chert which seems to be replacing biosparite. The arrow shows the vertical.

C. Negative print (actual size) of an acetate peel of sample L-8. Intraclastic biosparite is at top above a sharp contact with the underlying slightly mottled biomicrite. Note intraclasts included with fragmented fossils. The arrow shows the vertical.

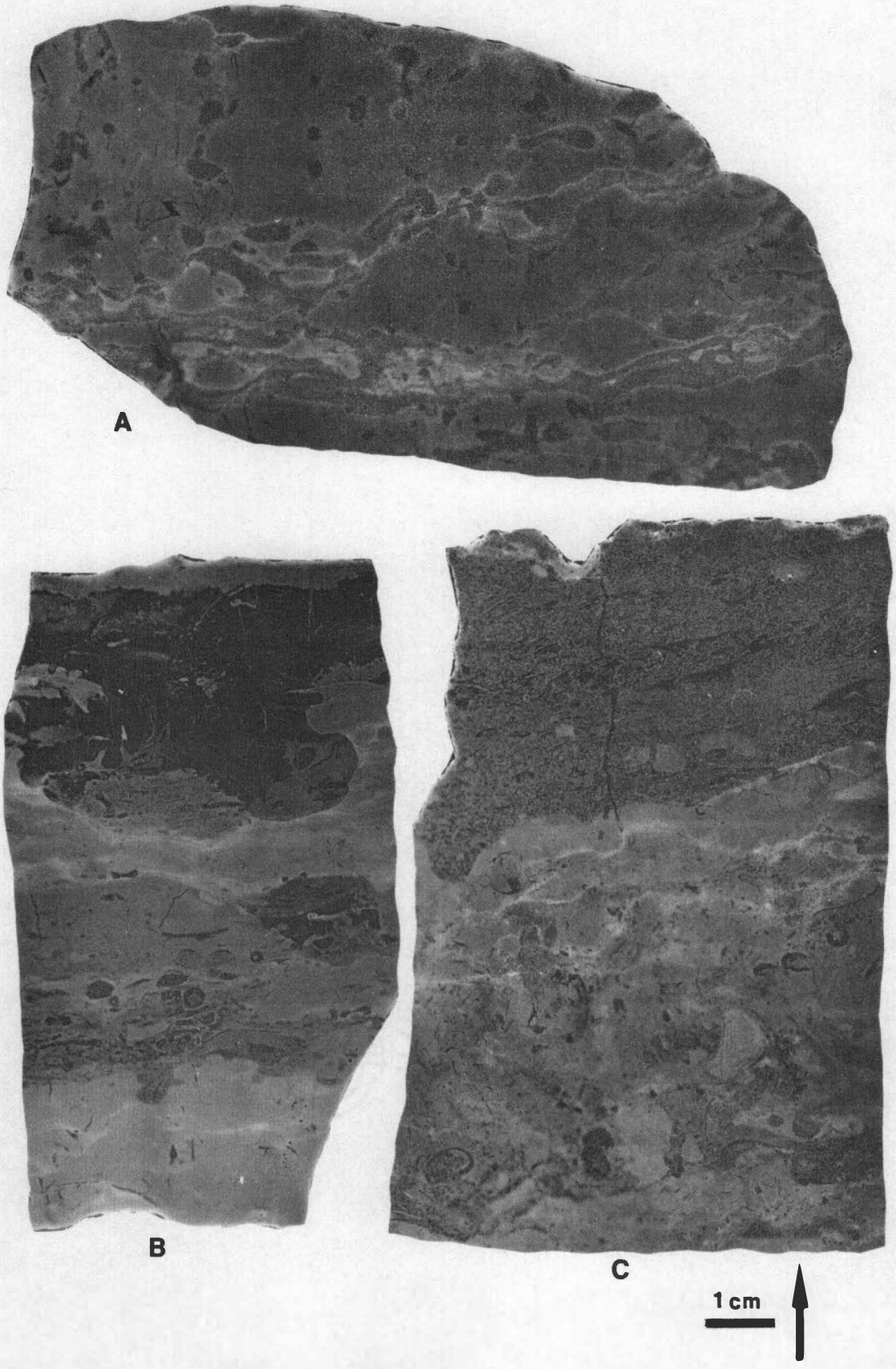

Figure 5. Lithology 1

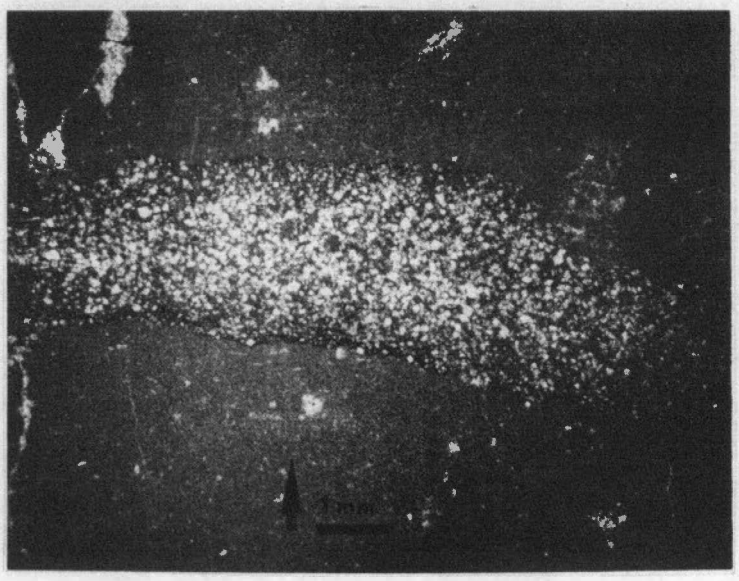

Figure 6. Photomicrograph of mottling in sample L 6 illustrating concentration of euhedral dolomite rhombs.

dolomite rhombs were observed to have shadowy ovoid centers reminiscent of pellets. Fossil fragments are occasionally associated with mottling. Contacts between mottling and enclosing micrite are often accompanied by pressure solution features. Mottling has been observed to grade laterally and vertically into restricted dark brown areas where dolomite rhombs appear to be stained and then on into stylolites of the same dark brown color (see Figures 7 and 8). The micrite-mottle contacts are otherwise sharp or gradational. The gradational contacts frequently have dolomite rhombs passing gradually into micrite.

The biomicrite portion of this lithic type varies in the amount of fossil material it contains. Fossil material, mostly debris visible at higher microscope power, ranges from none to 70 percent or more in some layers. Generally though, visible fossil debris is sparse. This is not to preclude the presence in abundance of submicroscopic fossil debris. In several thin-sections analyzed, pellets in the 100 to 150 micron range were observed associated with microspar and grading into micrite. It is quite possible that the micrite might properly be termed pelmicrite. The micrite may be in fact closely compacted pellets or at least pellets may be a main constituent.

In-life-position corals are associated with mottled biomicrite. Tabulate coral colonies as large as 14 inches across and many smaller ones were observed. Many of the colonies in Lithology 1 may be in like stratigraphic positions throughout the study area. Several colonies of tabulates, principally favositids, can be traced laterally across outcrops in some of the sections. One colony of Tetradium columnaria

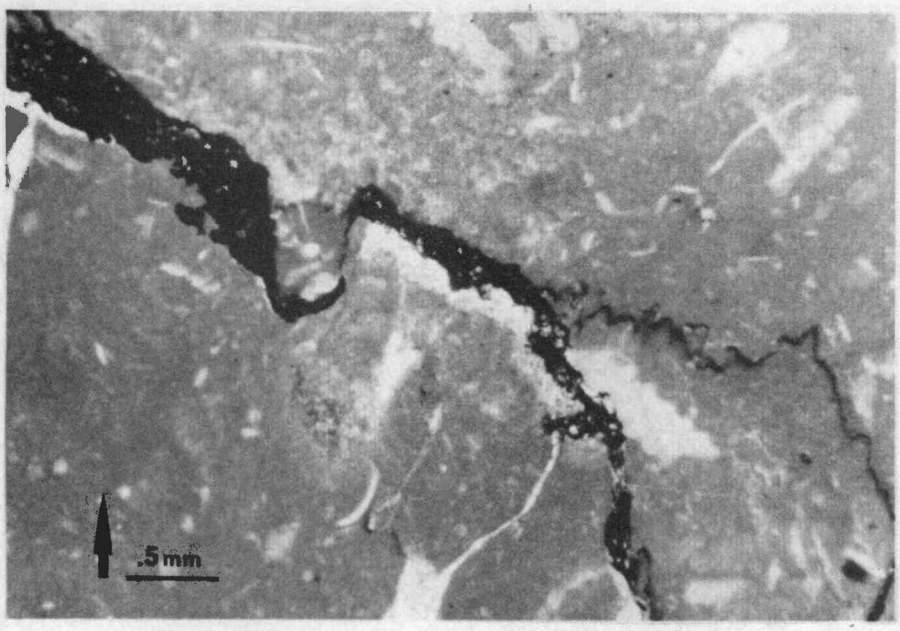

Figure 7. Photomicrograph of sample L 8 showing mottling grading into stained zone and then into stylolites.

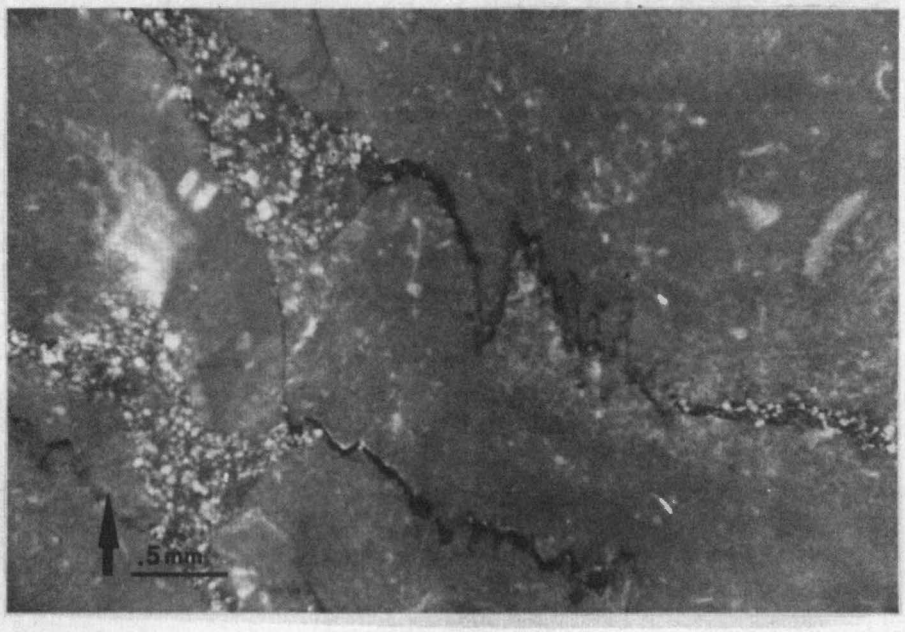

Figure 8. Photomicrograph of sample HC17 showing mottling filled with euhedral dolomite rhombs grading laterally into stylolites.

measuring 6-8 inches across, was observed at about the same horizon as smaller favositid colonies. Rare, articulated, spar-filled brachiopods and pelecypods were observed. Rugose corals which may or may not be in living position were also noted. Fallen trepostome bryozoan colonies and pelmatozoan stems were observed, but pelmatozoan, trilobite, algal, pelecypod, gastropod, brachiopod, and ostracod debris is the most abundant fossil material in the biomicrite (see Figure 5B, page 28).

The intraclastic biosparite consists principally of allochems in a sparry calcite matrix. However, micrite serves also as a matrix in portions of some of the samples studied. The contacts between this lithic type and the biomicrite are sharp, (Figure 5C page 28) and show little relief though they are not completely smooth. Some of the surfaces in cross-section appear to be current ripple marked. Ripple marks observed on bedding surfaces in outcrops trend about N5°W. Angular to subrounded intraclasts as large as 3 centimeters across are observed (Figure 5C page 28). Abraded fossil debris includes rugose coral, bryozoans, orthochonic cephalopods, algally-coated grains, echinoderm ossicles, brachiopods, trilobites, and ostracods. Other allochems detected are pellets which are ovoid shaped. The fragments within this lithic type are generally poorly sorted.

Lithology 11 is similar to the intraclastic biospartie, both with respect to gross lithology and its distribution within biomicrite. Lithology 11 differs from lithology 1 in that it is generally better sorted, fossil fragments and intraclasts are more abraded, fossil

content is chiefly pelmatozoan ossicles and bryozoan fragments and it is laminated to cross-laminated. Figures 9 and 10 show a comparison between the lithology 1 biosparite and lithology 11. Favositid tabulate corals are found in life position in this lithology. Figure 11 is a negative print of a peel typical of lithology 11.

Environmental Interpretation of Lithologies 1 and 11

The two lithic subdivisions of lithology 1 and lithology 11 are considered to be products of closely associated subtidal environments. The mottled biomicrite is believed to represent sedimentation in quiet water. A wide variety of sessile and vagile benthic biota is indicated by in-life-position fossils and fossil debris along with pellets observed in the micrite as well as in the mottling of some samples and suggestions of pellets in others. A prolific infauna is inferred from the extensive horizontal mottling which is attributable to burrowing deposit feeders. Fecal pellets which provided the primary texture of mottled areas and remain little changed in some samples have for the most part been overgrown or replaced by euhedral and subhedral dolomite rhombs. The mottled areas which were more permeable than the compacted muds probably served as channels through which sea water with a high level of salinity and high pH migrated. These are conditions essential to dolomite formation in experiments conducted by Lieberman (1967) and summarized in Bathurst (1971, page 536). This dolomite is probably early diagenetic possibly having crystallized at the time when overlying sediments were being altered by high intertidal and supratidal conditions in which dolomite was forming.

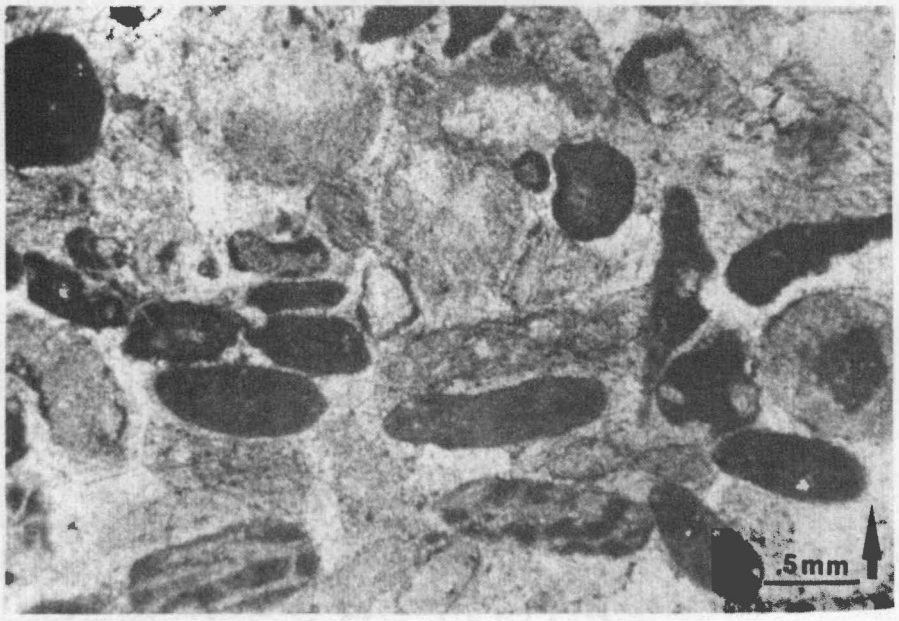

Figure 9. Photomicrograph showing sample HC14 of Lithology 11. The grains are fossils and intraclasts well sorted and rounded due to repeated abrasion.

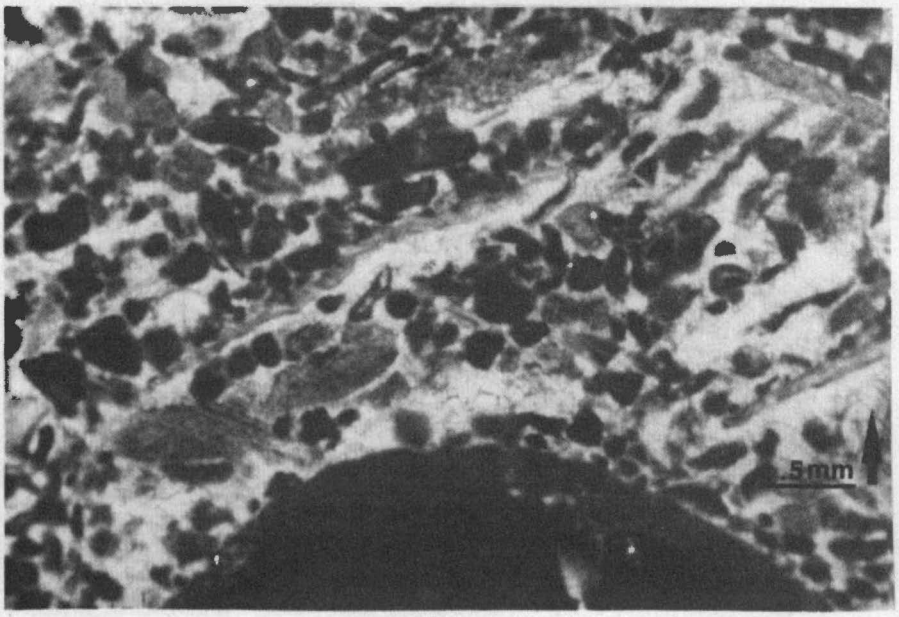

Figure 10. Photomicrograph of sample L-8 showing biosparite portion of Lithology 1. Note: Poorly sorted fossil fragments and intraclasts.

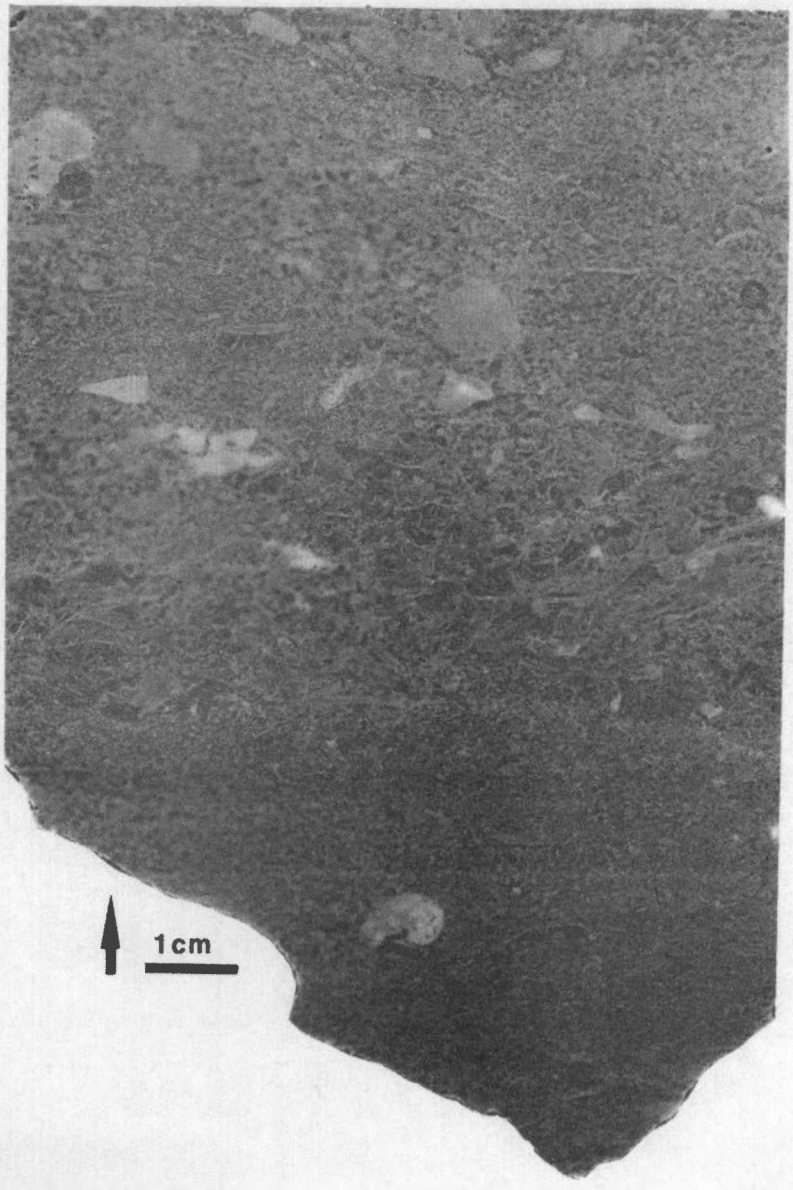

Figure 11. Negative print of peel of sample HC14 showing typical Lithology 11 texture. The orientation is normal to bedding as indicated by the vertical arrow and the print is actual size of sample.

Fallen articulated crinoid columnals, spar-filled articulated pelecypods and brachiopods, colonies of tabulate corals in living position, fragments showing little abrasion and long delicate bryozoan colonies are not completely fragmented indicate that the fossil debris in this environment has not been subjected to prolonged transport. It shows that they were deposited near their life site.

The intraclastic biosparite depositional environment is thought to have had a higher energy level than the mottled biomicrite because contacts between the two show some scour and fill (Figure 5C page 28). There is evidence of lumps of micrite becoming dislodged from the bottom and included as intraclasts in the overlying sediment (Figure 12). Fossil debris of the intraclastic biosparite lithic type bear strong resemblance to those of the burrow mottled biomicrite lithic type. They were probably concentrated by stronger than "normal" currents which eroded the biomicrite bottom and winnowed the fine mud from the coarser fossil debris. These deposits might also be considered lag deposits in broad shallow tidal channels (Walker 1973 page 25).

Lithology 11 may represent tidal channel deposits which were deposited in an environment of greater energy than suggested for the preceding. Greater abrasion of grains, more complete fragmentation of fossils, and sorting to a more uniform size are considered evidence of higher energy levels.

In summary, the environment of deposition suggested for rocks of lithology 1 and lithology 11 is subtidal normally quiet water

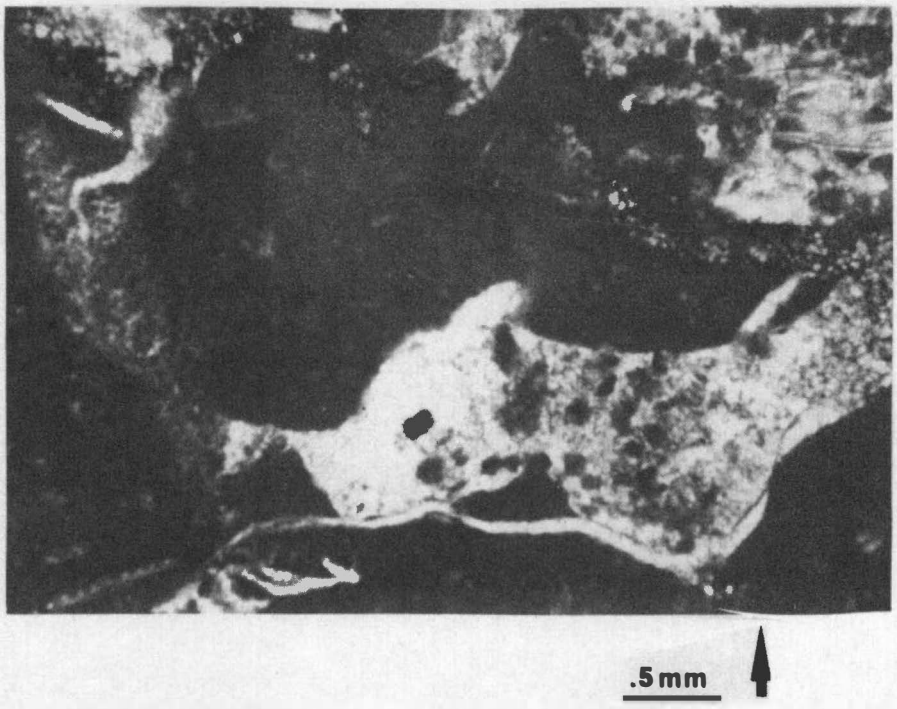

Figure 12. Photomicrograph of sample HC17 showing a part of the burrow mottled biomicrite of lithology dislodged from its original position and incorporated into the intraclastic biosparite porition of Lithology 1.

environment in which occasional turbulence caused concentrations of fossil debris by removing mud from the matrix. An environment crossed by tidal channels transporting and further fragmenting debris of organisms inhabiting the environment. Milici and Walker (1973) interpreted a portion of the Moccasin Formation with some of the characteristic of lithology 1 as subtidal "lake" deposits.

Analysis of Lithology 2 and 13

Lithology 2 and 13 are intricately related. Apparently lenses of lithology 2, three to four inches thick and a few feet wide rest stratigraphically upon altered volcanic ash. Analysis of samples of these lenses shows the matrix as a combination of microspar, micrite, and peloids. The term peloid (Bathurst 1971, page 547) is used because of the uncertainty as to the fecal origin of these allochem grains. It is strongly suspected that much of what appears to be micrite in thin-section, constituting about 20 percent of the rock, is actually clay. Refer to Appendix B for summaries of constituent particle analysis for lithology 2. The overall color of samples is nearly the same pale blue-green color of the underlying bentonite (lithology 13). Fossil debris and sparry calcite dominate the lenses. Fragments of pelecypods and gastropods are the main fossil constituents. Many of them are replaced, filled inside, and underneath by sparry calcite. Together these components constitute one half of the samples. A few large fragments of trilobites were observed and a fragment which appears to be the pygidium of Isotelus sp. is 2-1/2 inches across.

Bryozoans and pelmatozoan ossicles were other fossils observed. A negative print of a peel of one of the samples from a lens in the Litton section is shown in Figure 13A.

The lenses of lithology 2 are overlain and grade laterally into shale which has thin layers and lenses of lithology 2. The shale has many of the characteristics of the in situ bentonite below but seems to lose the color and other features away from the bentonite. The interval of alternating bentonite-like shale (lithology 13) and lithology 2 is overlain by a continuous layer of lithology 2 which has a few differences from the lenses below it. Material surrounding the still dominant molluscan fragments which are filled with sparry calcite or micrite, is more pelletal and less micrite. Much of the fossil debris other than the pelecypods and gastropods is in the sand size range. Figure 13B shows a high spired gastropod, 1-1/2" long, resembling Subulites sp. and a medium-spired one similar to Lophospira sp. was observed in another sample. The gastropods are partially filled with sparry calcite and micrite. Disarticulated pelecypod valves are found in abundance in some samples as in Figure 13C. They tend to be nested and partially filled with sparry calcite cement with many of them oriented convex side down. Trilobites, pelmatozoan ossicles, and bryozoan debris were observed as minor constituents in the various thin-sections analyzed. Figure 14 and 15 are photomicrographs of typical lithology 2 texture.

Environmental Interpretation of Lithologies 2 and 13

Volcanic ash fell into quiet subtidal waters, the depositional

Figure 13

Lithology 2

A. Negative print (actual size) of peel of sample L-12. This sample is from a lense of lithology 2 within lithology 13. The print shows gastropod, pelecypod, and trilobite fragments. Isotelus sp pygidium can be seen in the lower left corner.

B. Negative print (actual size) of peel of sample L-19. It shows mainly gastropod and pelecypod debris. Note longitidinal section of high spired gastropod probably Subulites sp., in the lower right quarter.

C. Negative print (actual size) of peel of sample P-22. It shows nested pelecypod values some with sparry calcite filling underneath. Gastropod and trilobite debris also present. The matrix is pelsparite.

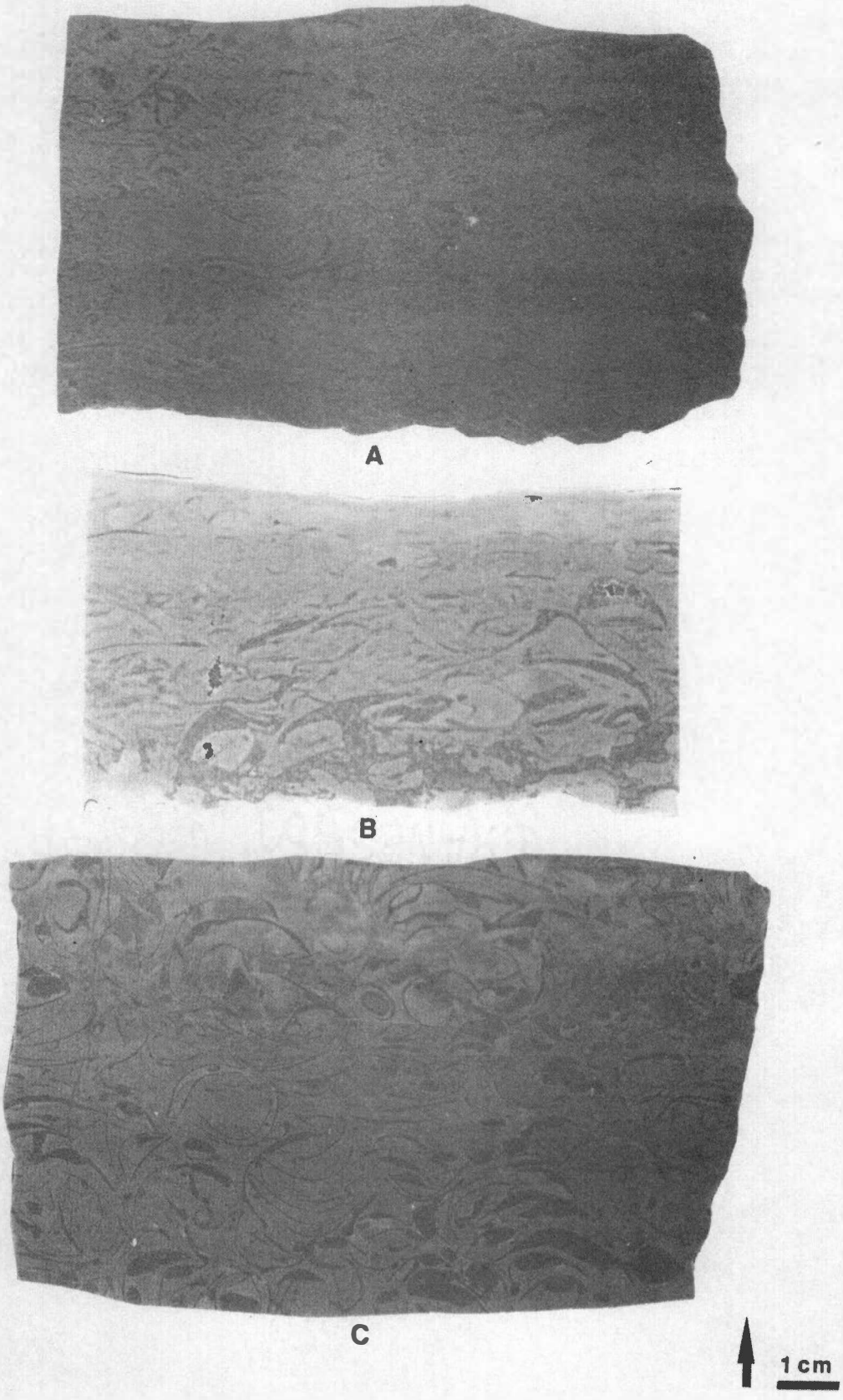

Figure 13. Lithology 2

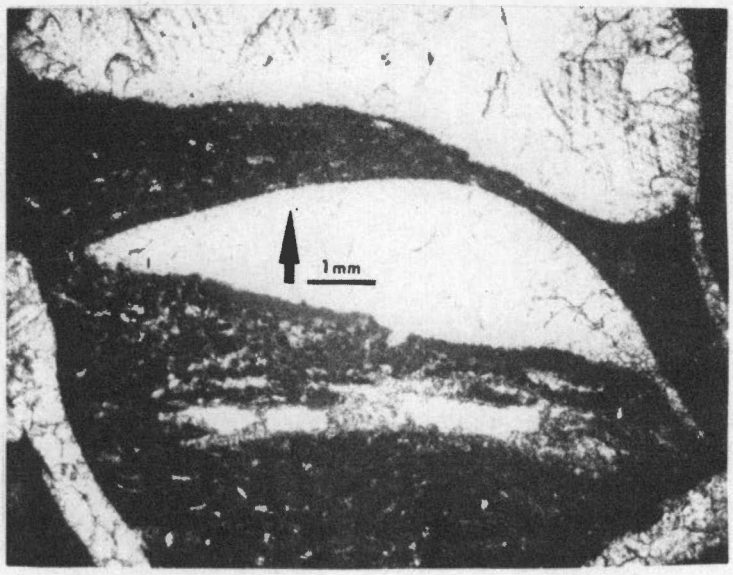

Figure 14. Photomicrograph of Lithology 2 showing typical texture of sparry calcite filled pelecypod valves in a pelmicrite matrix.

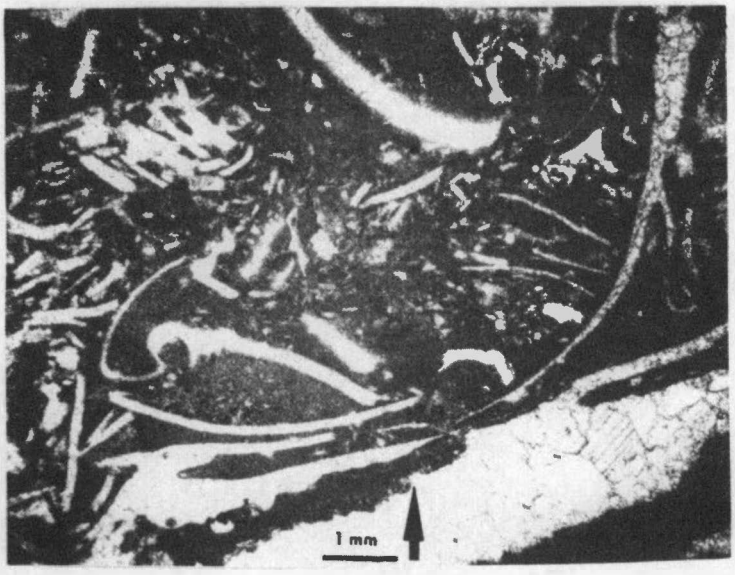

Figure 15. Photomicrograph of Lithology 2 showing gastropod and pelecypod fragments.

medium postulated for lithology 1, resulting in a ubiquitous blanket. The thickness of the ash was probably much greater than its present alteration product which is approximately 21 inches of "bentonite". Assuming an original water content of more than 50 percent which is common in Recent muds, the original thickness of the ashbed was probably at least 2 and perhaps 3 times the present thickness of bentonite (thus, 4 to 6 feet). The ash fall brought sudden environmental change, probably killing much of the diverse fauna living in the subtidal water prior to it. Lenses of lithology 2 probably represent the re-establishment of organisms on the clayey bottom of small ephermeral ponds. Gastropods, pelecypods, and trilobites were dominant in these subtidal waters along with occasional bryozoans and brachiopods. Alternation of clay shale and thin layers of lithology 2 resulted from currents reworking the bentonite over the areas inhabited by carbonate generating organisms. The continuous layer of lithology 2 overlying the alternating layers of shale and biomicrite is interpreted as being of subtidal origin. A high energy level is indicated by the arrangement of bivalve shells in "over-turned" and nested positions. The fauna was more diverse than that found in lenses of lithology 2 within the bentonite but not as variable as that of lithology 1.

Analysis of Lithology 3 and Sublithologies 4 and 15

Constituent particle analyses of several thin-sections, summaries of which are included in Appendix B, show micrite constituting approximately 90 percent of lithology 3, spar about 10 percent, fossil fragments

present only in trace amounts. There is a question about the composition of the micrite. It is possible that the micrite is composed principally of closely compacted pellets (pseudopellets?) or possibly fine fragments of fossils. The term pseudopellet has been suggested by Fåhraeus et al. (1974 page 27) to describe rounded or ovoid grains derived from mechanical breakdown of deposits of fine sediment. The micrite is laminated at all scales (Figures 16 and 17) including microlamination from 50 to 400 microns thick. Figure 18A and B are negative prints of peels of samples that show lamination typical of lithology 3.

There is an abundance of desiccation cracks and birdseyes filled with sparry calcite (Shinn 1968). Some of the small vertical, sparry calcite and microspar-filled areas, 50 to 100 microns across, may be burrows owing to their association with laminae surfaces and the fact that the bottoms are rounded. Another possibility is that they might be algal tubes. The latter possibility is particularly appealing when the photomicrograph included as Figure 17 is inspected. Many of the larger cracks show irregularites possibly due to vertical compaction upon subsequent burial. A few of the vertical spar filled areas give the impression of burrowing and others may be gas tracks. However, these areas are more than likely large desiccation cracks associated with polygons 2 inches across observed on bedding surfaces in the field. Slump areas filled with calcite and intraclasts such as shown in the center of Figure 18B also were observed. Observation of the desiccation evidence indicates that the cracks are dominantly shallow, crossing only a few laminae, and measuring only a few tenths of a millimeter wide.

Figure 16. Photographs of the Litton section outcropping of Lithology 3. Handlens on top of the outcrop is 4 centimeters. Note the thin laminations.

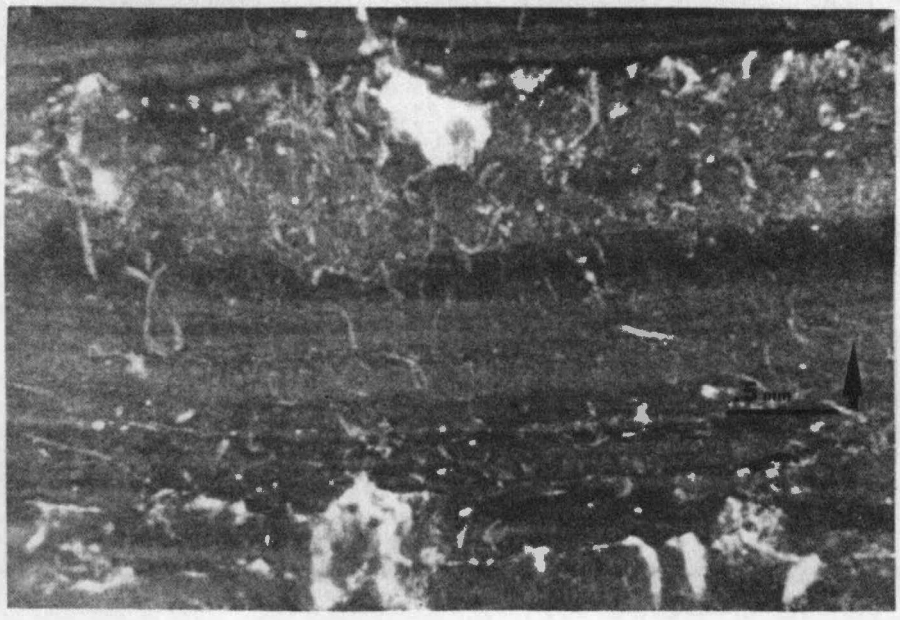

Figure 17. Photomicrograph of laminated Lithology 3. Notice the very small vertical spar filled areas possibly algal tubes, desiccation cracks or burrows.

Figure 18

Lithologies 3 and 4

A. Negative print of peel of sample L-24 showing the thin laminations typical of lithology 3. It also shows spar filled cracks and interlaminar calcite. (Actual size).

B. Negative print of peel of sample P-28 showing laminations, sparry calcite filling desiccation cracks, and birdseyes. (Actual size)

C. Negative print of peel of sample L-27. Lithology 4 intraclastic zone within lithology 3. Note the light colored layer which is dolomite. It apparently has been broken into intraclasts deposited with the overlying sediment. (Actual size)

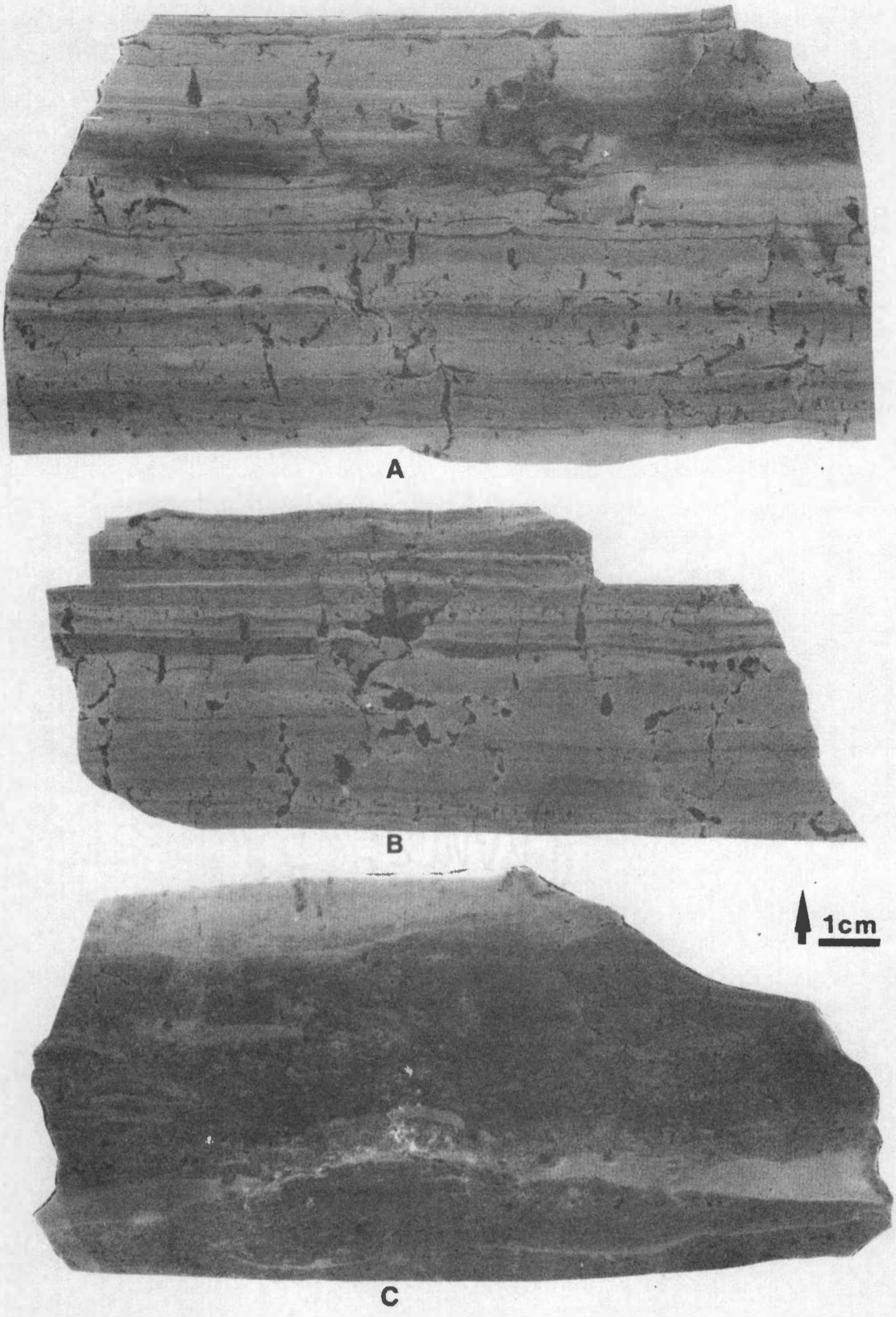

Figure 18. Lithologies 3 and 4.

Some laminae, perhaps about 20 percent of them, have an abundance of sparry calcite birdseyes and there are small horizontal fractures filled with microspar 100 to 300 microns thick and extending 2 or 3 millimeters between laminae.

Fossils are rare and limited to a few concentrations of calcite-replaced bivalves and gastropods.

Lithology 4 is closely associated with lithology 3 and occurs as thin intraclastic zones and layers within lithology 3. It also occurs with some of the other principal lithologies to be described later. The present references to lithology 4 are only for those occurrences in lithology 3. Microscopic analysis of several lithogy 4 samples discloses that from 47 to 76 percent of the constituents are intraclasts that are subangular to rounded. The intraclasts are elongate, a few 100 microns to about 2.5 centimeters across, and dolomitic. See Figure 18C page 47. Fossil fragments account for only a few percent of the allochems. They consist of pelecypods, gastropods, brachiopods, fragments and pelmatozoan ossicles. The pelecypods and brachiopods are generally nested concave side up. Much unidentifiable fossil debris possibly represents greatly reduced fragments of the organisms named. Spar is present as cement and as fossil replacement. Sparry calcite in large 10-12 mm patches fill voids beneath disarticulated bivalves and brachiopods.

Lithology 15 is associated with the top of lithology 13 in several sections. A constituent particle analysis, which is included in Appendix B, shows that more than 50 percent by volume is dolomite.

Dolomite occurs as rhombs 0.01 millimeter across and spaced about 0.02 millimeters apart as shown in Figure 19. Accompanying some of the dolomite rhombs are reddish to yellowish brown stains. The volume of micrite is about 30 percent. A high percentage of this fraction is thought to be argillaceous material. Sparry calcite is rare and is present as horizontal birdseyes and as fillings of unidentified fossils. Lithology 15 is cracked by desiccation into polygons 1-1/2 to 2 inches across (Figure 20) with cracks a centimeter wide. The polygons tend to breakup into round masses upon weathering. In the Litton and Pee Dee Ridge sections, an intraclastic zone (lithology 4) bears strong resemblance to lithology 15.

Environmental Interpretation of Lithologies 3, 4 and 15

Lithology 3 is thought to be the product of tidal flat deposition. The laminations probably represent organosedimentary planar structures formed by the activity of algal mats in binding fine particulate sediments. Accounts of Recent occurrences are found in the work by Logan and others (1964), Gebelein (1968), and Scoffin (1970) etc. Calcite filled areas a few microns across and primarily vertical may be tubes formed by filaments of algae. Characteristic spar-filled vertical mudcracks and interlaminar birdeyes are evidence of desiccation of the sediment when exposed subaerially. Vertical cracks within laminae or crossing only a few are considered to represent short periods of exposure and are related to thickness of laminae (Anderson, et al., 1965 page 5 and Walker, 1973, page 22). Polygons 2 to 3 centimeters wide and crossing several laminae were observed associated with 4 to 8

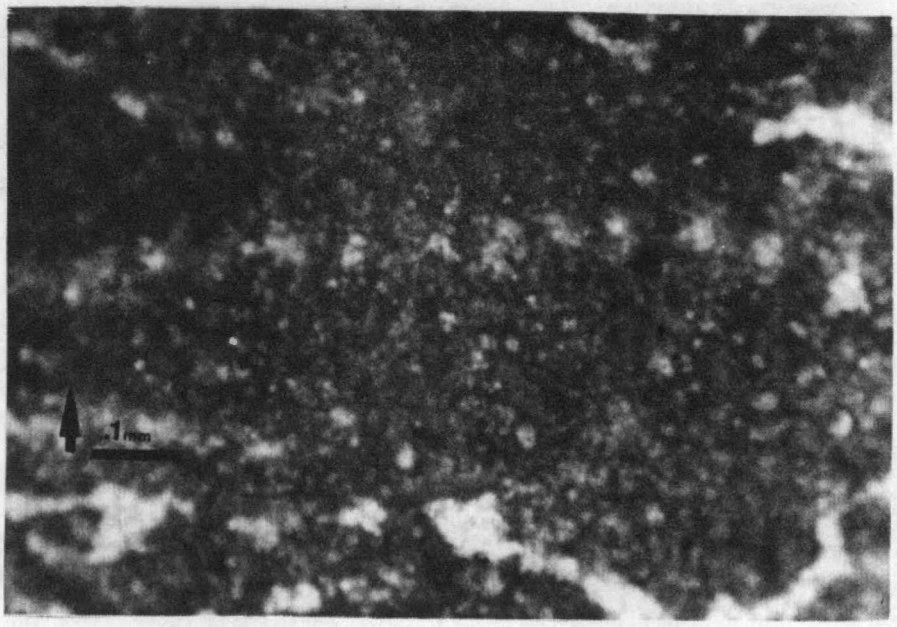

Figure 19. Photomicrograph of sample HC46 which shows the abundance of dolomite rhombs in Lithology 15. Calcite birdseyes are also visible.

Figure 20. Photograph of Lithology 15 outcrop at Howard Cemetery section. It weathers into large 8 to 10 centimeter rounded areas which are mud crack polygons. Handlens is 4 centimeters.

centimeter wide polygons on bedding surfaces. The wider polygons are thought to represent longer periods of desiccation. Vertical burrowing is suspected as evidenced by vertical spar-filled and other wavy micrite and spar-filled areas. Some of these problematical burrows are a millimeter or so wide and 2 to 3 centimeters long. A few fossil fragments were observed in discrete patches. They are disarticulated pelecypods and are considered to be fossil debris brought in from a more seaward environment by tidal currents and incorporated with the intertidal sediments. The rare fossil content of this lithology indicates an environment inhospitable for organic activity (excluding the algae).

Periods of extended subaerial exposure are indicated during and subsequent to the deposition of sediments preserved as lithology 3. Lithology 4 is composed of intraclasts of what appear to be fragmented desiccation polygons of a dolomite crust. Figure 18C page 47 shows light bands of dolomite which are broken into angular to subrounded fragments and deposited in an intraclastic zone above. Shinn, et al. (1965) and many other workers in Recent carbonate environments have noted crusts of dolomite forming under supratidal conditions.

Lithology 15 probably represents dolomitized lithology 3 and may grade laterally into lithology 4 in the northeastern part of the study area. Lithology 15 may represent longer periods of desiccation because it is thicker and mudcracks are wide and deep and expressed as 1-1/2 to 2 inch polygons on the bedding surface.

In summary, lithology 3 is considered to be lowest intertidal, in the zone that was most likely to be covered by sea water the longest

during the tidal cycles. However, periods of desiccation allowing time for thin 1 to 2 centimeter crusts to form, subsequently to be mudcracked, ripped up from the bottom by normal or possibly storm tides, and deposited as an intraclastic zone to be covered over by intertidal sediments.

Analysis of Lithology 5

Thin-section analysis of lithology 5 shows two lithologies alternating as ultrathin wavy laminations a few tens of microns thick to thin beds a little more than a centimeter thick. The more abundant of the two is pelmicrite with an abundance of dolomite rhombs and occasional calcite-filled vertical and interlaminar desiccation cracks. It may be considered dolomitic limestone or dolomite in most cases. The other principal lithology is pelsparite. It contains an abundance of birdseyes and interlaminar calcite. Dolomite layers are sometimes jumbled as angular to subangular thin intraclastic zones. Figure 21 A, B, and C show typical features of lithology 5.

Rare concentrations of fossil debris, mostly disarticulated pelecypod valves were observed. Wavy laminae pinch and swell and very often portions of the pelsparite with abundant birdseyes appear as lenses (see Figure 21A). This possibly results from compaction as well as expansion where desiccation is at maximum. Possible vertical burrows were observed in several samples.

Environmental Intepretation of Lithology 5

Characteristics exhibited by this lithology have been described by workers in Recent as well as ancient carbonates as those of supratidal

Figure 21

Lithology 5

A. Negative print (actual size) of peel of sample L-44 which shows typical alternation of dolomitic limestone (light color) and pelsparite with abundant interlamina birdseyes. Note lens-like pelsparite concentration in upper right corner.

B. Negative print (actual size) of peel of sample B-32 shows the abundance of dolomitic limestone with a large desiccation feature in the lower right side.

C. Negative print (actual size) of peel of sample L-45 which shows wavy thin laminations of alternating dolomitic limestone and lens-like pelsparite with birdseyes.

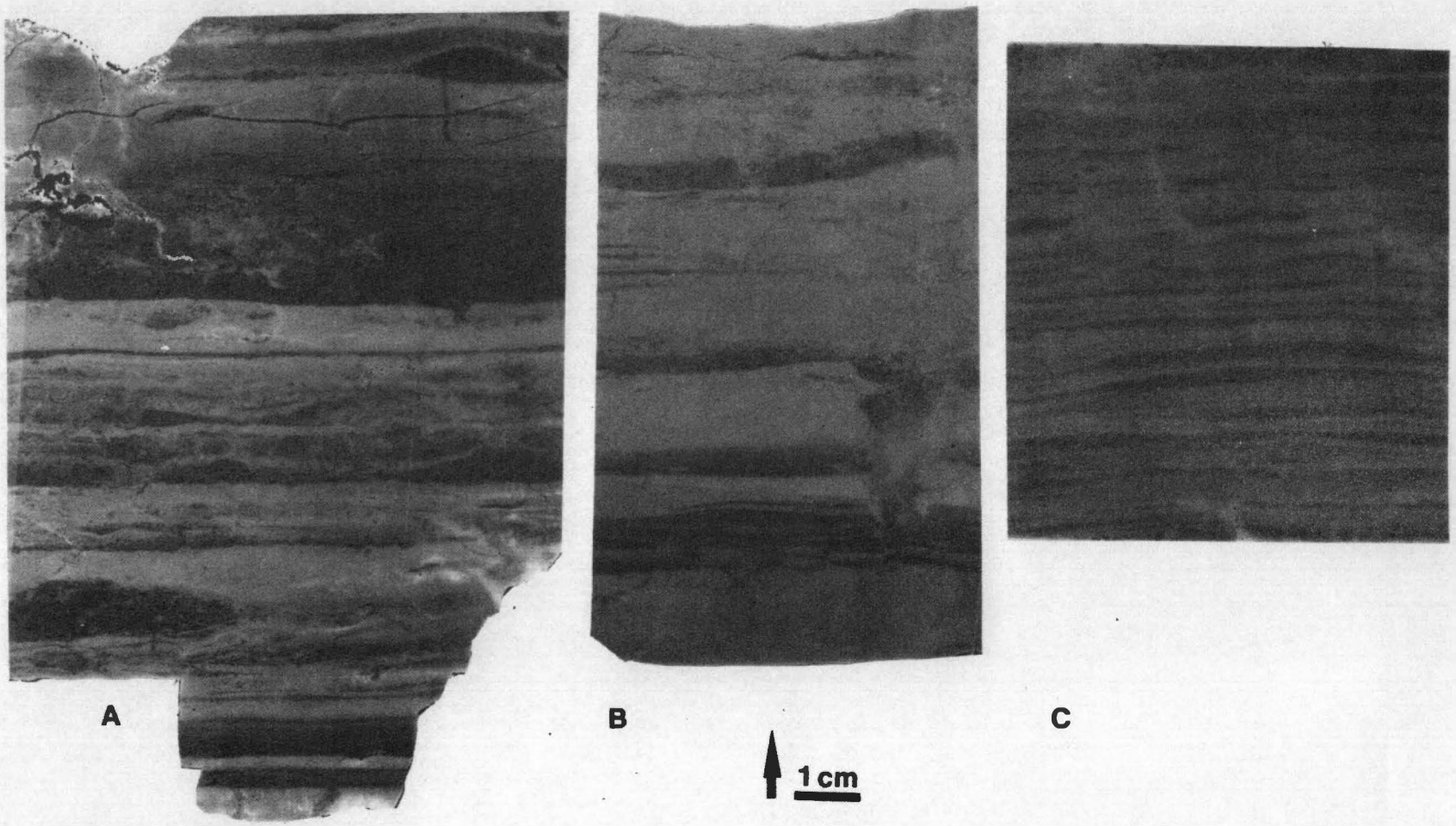

Figure 21. Lithology 5

origin. Laminae formed by sediment binding algae are reported from Recent supratidal and intertidal environments by Ginsburg et al. (1954) and Logan (1961). The restriction of the formation of dolomite layers to the supratidal environment as reported in modern studies by Shinn et al. (1965) and others leads one to believe that at least some of the layers of lithology 5 have supratidal origins. This conclusion is further supported by the presence of abundant vertical mud cracks, interlaminar cracks, and birdeyes filled with sparry calcite. These characteristics are particularly abundant in the pelsparite layers. These desiccation features are typical of recently deposited supratidal and intertidal sediments as reported by Shinn (1968). Rare concentrations of fossil of limited taxononic variety were probably washed in from adjacent marine environments. All of these characteristics are evidence that the depositional environment was above the strand line most of the time and lithology 5 is assigned therefore to a high intertidal-supratidal depositional environment.

Analysis of Lithology 6

Lithology 6 thin-section and peel analyses reveal that there is an abundance of pelmicrite and disseminated dolomite rhombs. The rhombs are difficult to distinguish because they are mostly in the 2 to 10 micron size range. However, some are 50 to 100 microns across. Point counts show around 18 percent dolomite but it is felt that the actual content is much higher. Peloids are about 30 microns by 100 to 200 microns and somewhat translucent as can be seen in Figure 22. Figure 23 shows the same lithology at lower power.

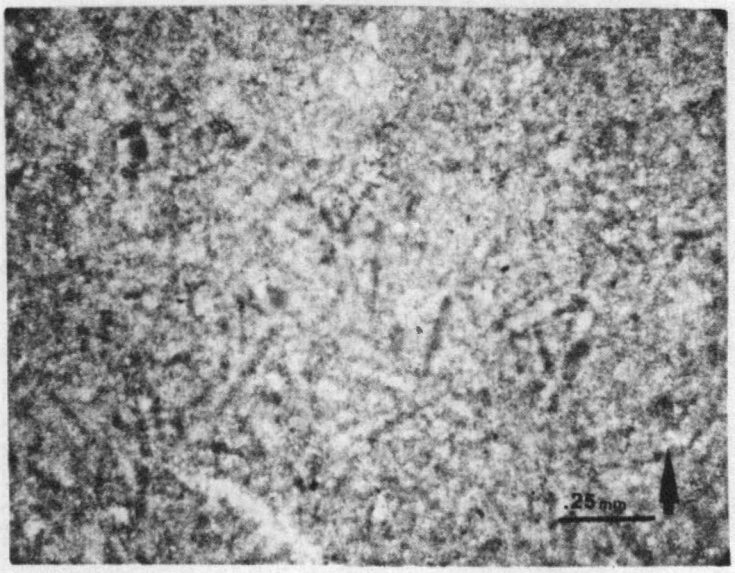

Figure 22. Photomicrograph of sample P-49 of Lithology 6 elongate translucent peloids are shown.

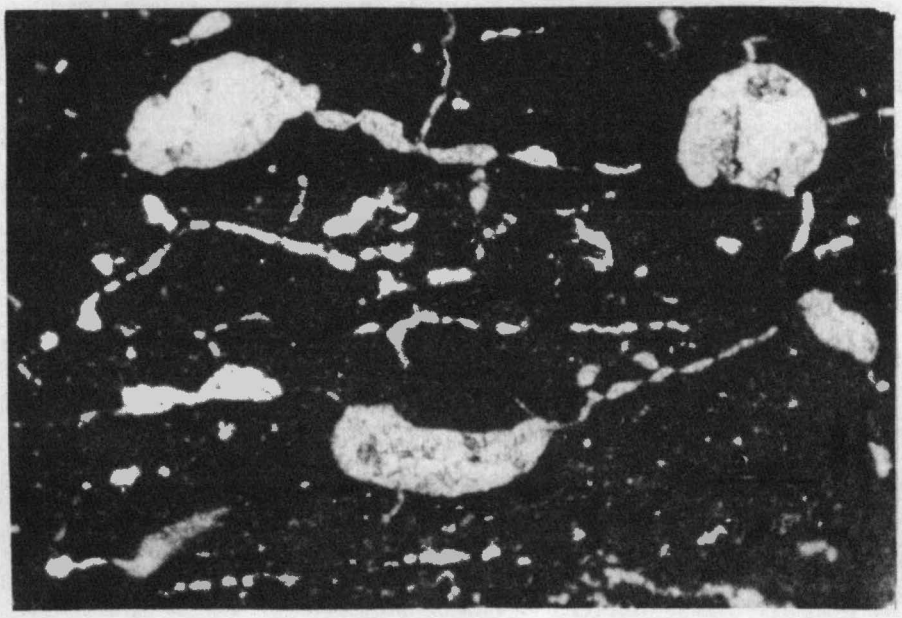

Figure 23. Photomicrograph of sample P-48 of Lithology 6 which shows round to irregularly round birdseyes connected by interlamina calcite.

Laminae are irregular and thin. They can be traced readily due to the presence of abundant interlaminar calcite. Figure 23 and figure 24 A, B, and C reflect general characteristic of lithology 6. Birdseyes with round to irregularly round shapes, 2 to 3 millimeters or less in diameter are sometimes connected by interlaminar calcite and sometimes by calcite filling vertical desiccation fractures. Mudcracks are abundant. In Figure 25, a photograph of the lithology 6 outcrop at the Litton section, extensive mudcracking can be observed. Also the relationship between mudcracking and the irregular lamination can be seen when the figure is examined closely. Intraclastic zones containing intraclasts with lithologies characteristic of lithology 6 can be seen in some samples. Figure 24C shows a zone of angular to subround intraclasts. One zone of subangular to round intraclasts near the top of lithology 6 can be correlated between sections. A few highly fragmented and thus unidentifiable fossils found only in small concentrations with intraclasts were observed in lithology 6.

Environmental Interpretation of Lithology 6

The environment of deposition for lithology 6 is designated as supratidal for the following reasons: 1. abundance of dolomite rhombs in the pelmicrite; 2. The abundance of birdseyes, interlamina, and vertical, calcite filled, shrinkage cracks which apparently developed over an extensive period of subaerial exposure causing the laminae to assume undulating forms. (growth expansion of algal mats might also cause undulation); and 3. Rare and highly fragmented fossils only. Figure 24 A and B show extensive deformation of the laminae in lithology 6.

Figure 24

Lithology 6

A. Negative print (actual size) of peel of sample L-47 showing typical characteristic of lithology 6. The thin irregular lamination and abundant interlamina birdseyes.

B. Negative print (actual size) of peel of sample P-49 showing much the same characteristics as Figure 24-A. Notice the upwarped area near bottom on the right.

C. Negative print (actual size) of peel of sample L-46 showing intraclastic zone near the bottom.

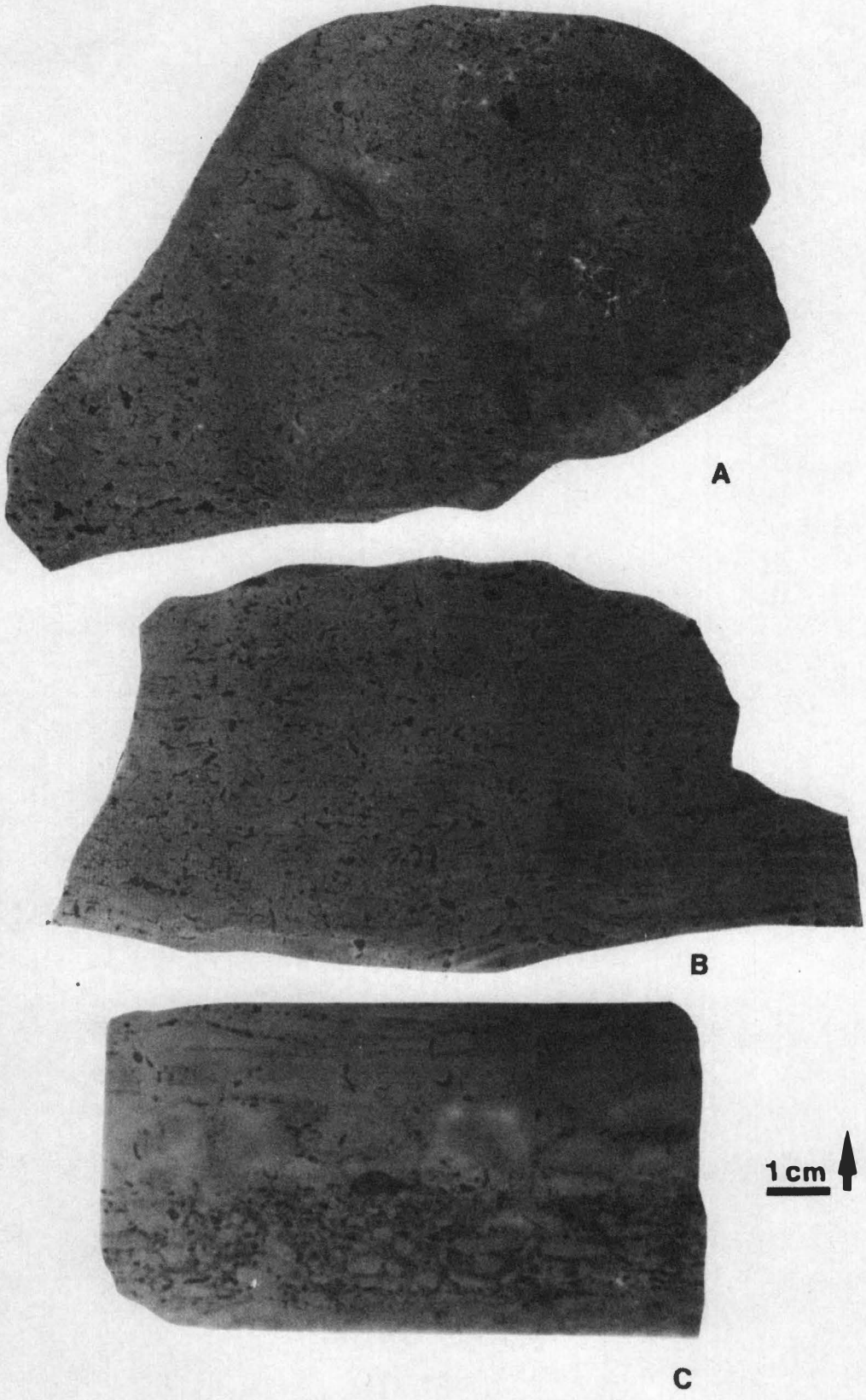

Figure 24. Lithology 6

Figure 25. Photograph normal to bedding of Lithology 6 outcropping in the Litton section. Note the relationship between cracking and irregular lamination. Handlens is 4 centimeters long.

which are similar in appearance to photographs of recent supratidal dolomite included by Shinn (1968) in his report.

Analysis of Lithology 17

Lithology 17 occurs only in the McWilliams Creek section and overlies lithology 5, in the same straigraphic position as lithology 6. An analysis of peels and polished samples shows this lithology to be unique in the study area in basically 2 ways. The color is greenish gray and grayish red purple and the rock has a high insoluble residue content. The insoluble residue is approximately 50 percent by volume and is composed largely of clay. Mudcracks one millimeter wide with polygons about one half to one inch across are observed. Vertical burrowing may be responsible where the sediment has a churned up appearance. These areas are 1 to 2 millimeter wide, vertical and irregularly mottled. Laminations a few microns to nearly 1 centimeter thick are present. Lighter colors are associated with the cracks and the reddish purple color is in the areas less affected by desiccation. Rare ostracod valves and trilobite fragments are found in some of the samples.

Environmental Interpretation of Lithology 17

The environment of deposition for lithology 17 is probably closely related to lithology 7 except for color and higher clay mineral content. The color may be related to weathering since the section is in a creek bottom, but rocks of similar lithology overlying this interval does not have the red purple color. The lighter colors

associated with mudcracks which cross the red purple areas tend to indicate that the color is primary or early diagenetic. The Moccacin formation studied by Milici and Walker (1973) also shows this lithology in the mudbank facies. The features indicated above may have developed when carbonate muds of high clay content were subaerially exposed in a supratidal or high intertidal environment.

Analysis of Lithologies 7 and 14

Lithology 7, present in all sections, was analyzed microsopically and found to consist of layers and lenses of pelsparite within a pelmicrite to micrite. The pelmicrite to micrite constitutes most of this lithology. The layers and lenses of pelsparite pinch and swell and are occasionally 2 centimeters or more thick. Inside the layers and lenses of pelsparite horizontal cracks are filled with calcite and connect with 0.5 millimeter birdseyes. Some of the pelsparite lenses and layers have fossil debris and calcite-filled voids beneath ostracod valves and trilobite fragments. Medium-spired gastropods filled with calcite are also found in these zones. Often mudcracks or possible burrows connect the areas of pelsparite through the pelmicrite layers. Areas 2 millimeters in width nearly filled with pelsparite and sparry calcite are suggestive of vertical and horizontal burrowing. Other areas within the pelmicrite, .5 to 1 millimeter across, have curved to rounded, partial sparry calcite fillings. These are possibly also burrows. Figure 26 A, B, C, and D show typical lithology 7.

The lens-shaped areas, often observed in peels and thin-sections, sometimes truncate laminations in the pelmicrite. This is especially

Figure 26

Lithology 7

A. Negative print (actual size) of peel of sample P45 of lithology 7 shows typical interlaminated pelmicrite (light color) and pelspiarite (dark color) with abundant birdseyes and vertical burrows filled with calcite.

B. Negative print (actual size) of peel of sample HC56 lithology 7 showing two basic lithologies pelmicrite (light color) and layers and lenses of pelsparite (dark color).

C. Negative print (actual size) of peel of sample L-53 of lithology 7 shows concentric desiccation cracking, burrowing, and also shows truncation of laminae by scour and fill. Note fossil fragments in the feature in upper right corner. Also note mound-like features that may be piles of pellets at vertical burrow mouths.

D. Negative print (actual size) of peel of sample P-56 lithology 7 shows scour truncating laminations and subsequent fill which includes spar-filled gastropods.

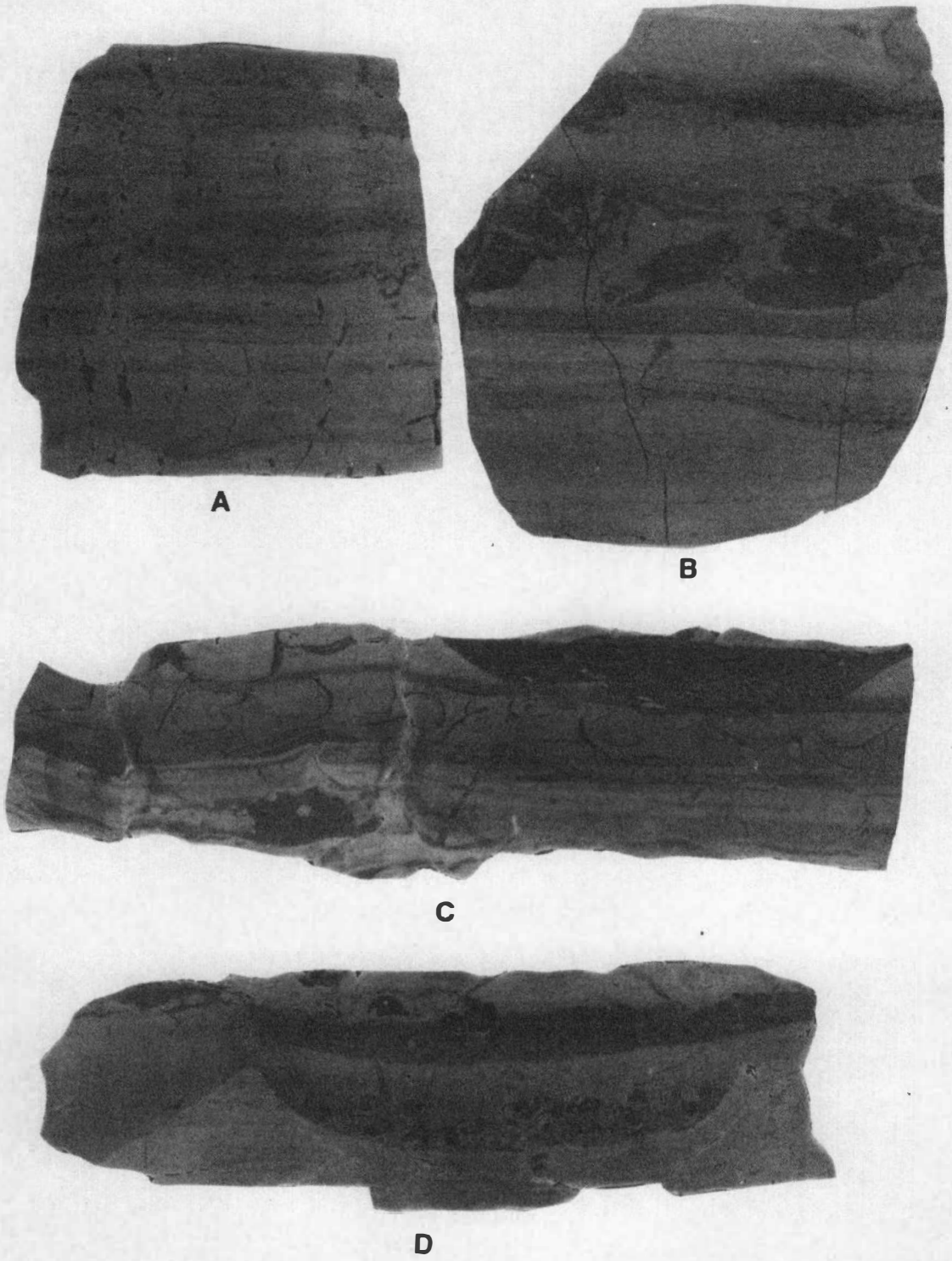

Figure 26. Lithology 7

true of areas with concentrations of fossils. Figure 26C and D show the truncation of laminae. Some of the lens-shaped areas of Figure 26C appear to be associated with burrows and may be piles of pellets at vertical burrow mouths. Ostracod valves are often concave side up in these areas. Some of the fossils have micrite filling and enveloping them. Pelmicrite intraclasts with fossil inclusions were also observed.

Lithology 14 occurs as a thin layer in the McWilliams Creek and Howard Cemetery sections. The unit consists of cross-laminated pellets between 80 to 100 microns in diameter with a spar and micrite matrix. The pellets are rounded and slightly elongate. The cross-laminations slope as much as 35° from the horizontal in some places. Ripple drift is exhibited in some of the samples. Intraclasts that are subrounded to rounded are observed to be as much as 8 to 10 millimeters long. Occasionally pelecypods, ostracods, and brachiopods are replaced by calcite and some have calcite filling voids beneath them.

Environmental Interpretation of Lithology 7 with 14

The depositional environment suggested by the analysis of lithology 7 is the intertidal zone. The presence of abundant mudcrack polygons, horizontal, spar-filled desiccation cracks and birdseyes (Shinn, 1968), and abundant vertical burrows (Walker, 1973, Laporte, 1971) suggest an intertidal origin. Concentrations of pellets near the mouth of burrows may indicate suspension feeders. The laminations within the pelmicrite layers and pelsparite layers and lenses as well, may confirm the presence of sediment binding algae with only the sediment and little

or no organic material remaining. The lenses that truncate laminae and are often filled with fossil debris consisting of abraded ostracod trilobite, and gastropod fragments may represent scour and subsequent fill from the action of tidal currents moving across muds. The presence of a few fossil concentrations of limited diversity are a possible indication that they have been brought into the environment by currents. Ostracods and trilobites as the most abundant fossils are an indication of intertidal or tidal flat conditions according to Laporte (1971 page 727).

The presence of a thin layer of lithology 14 with its cross-laminations and uniform size, may mark the presence of a tidal delta, tidal channel, or a current capable of sorting these fine particles.

Analyses of Lithology 8

Analyses of lithology 8 thin-sections show the principal constitutents to be micrite, spar, and pellets varying in proportions from sample to sample but totaling 90 volume percent. The other 10 percent consists of fossils and fossil fragments. The matrix of this lithology grades from pelsparite, to pelmicrite, to micrite. There are also large portions of this lithology that are considered biosparite.

The lower portion of lithology 8, is generally more pelsparite and pelmicrite than micrite. Some areas have only a few fossils distributed in the matrix. Fossils are mostly assembled in a sparite matrix in lens and thin bed concentrations reminiscent of those in lithology 7 below, see Figure 27. Several samples have burrow mottling which is mainly vertical; however, some mottling is horizontal. Figure 28

Figure 27. Negative print of a peel of sample P 68 typical of lithology 8 texture. Pelmicrite is the lighter color which shows mottling and biosparite layers and lenses the darker colors. Actual size of sample.

Figure 28. Negative print of a peel of sample P 69 showing possible burrow mottling of Lithology 8. Notice what might be a U-shaped burrow just right of center and note concentric sparry patches associated with rounded to ovoid mottling. Actual size of sample.

shows a U-shaped burrow along with other areas which may represent burrow mottling. Some of the vertical burrows are filled with spar while others are filled with micrite. Some areas that appear to be burrows are thought to be longitudinal cuts of Tetradium sp. filled with micrite and sparry calcite because of the straightness of the sides. One such area runs diagonally across the bottom of Figure 27.

The semicircular-shaped patches of sparry calcite filling voids in Figure 28 are thought to be related to shrinkage in the micrite. These features are considered voids because irregularities of the opposing sides tend to match. These separations may be due to the burrowing of filter feeding organisms. The burrows may be the areas where shrinkage occurs allowing for opening of semicircular cracks. Another plausible cause might be intrasediment slumping (see Figure 29) which is common in this lithology. It is thought that the slumping may be associated with the dissolution of corallites of Tetradium sp. such as shown in Figure 30.

Fossils found in lower part of lithology 8 are quite varied and include fragments of Tetradium sp. along with pelmatozoan ossicles, trilobites, gastropods, bryozoans, and brachiopods. Near the top of the unit massive Tetradium sp. in living position dominates. Figure 31 shows a bedding surface where a Tetradium sp. colony about 0.5 meters across is weathering out. Figure 32 is a negative print of a peel of a sample of lithology 8 which shows upward branching coralla surrounded by and sometimes filled by micrite. Also included are pelmatozoan ossicles, gastropods, trilobite debris, brachiopods

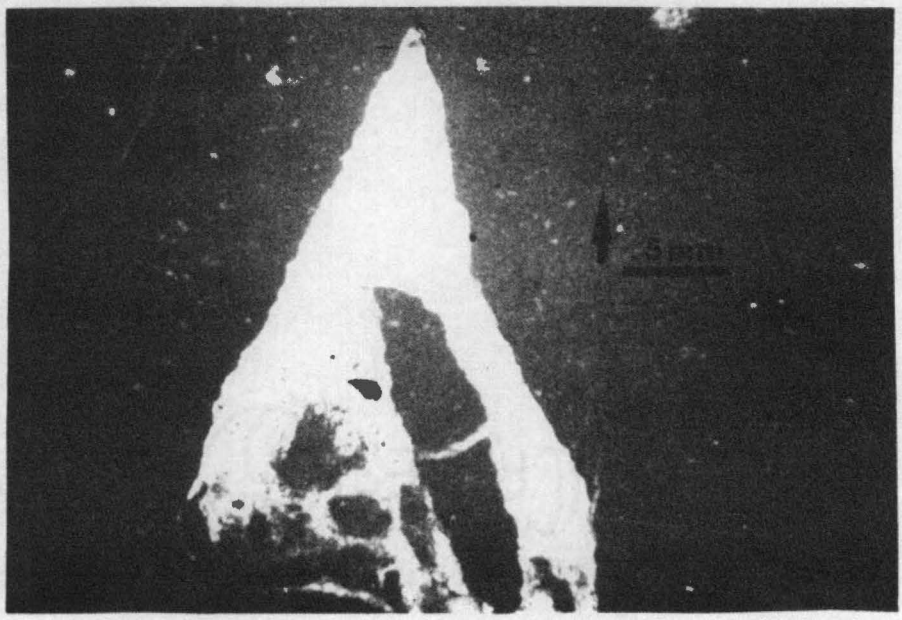

Figure 29. Photomicrograph of sample HC71 of Lithology 8 a collapse structure in micrite. Note angular fragments of micrite a bottom of spar filled cavity.

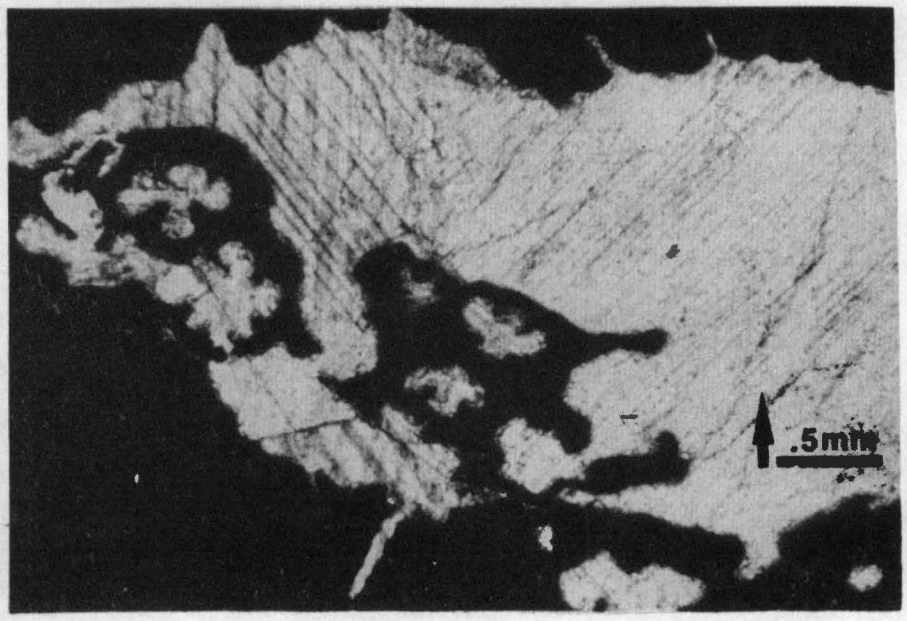

Figure 30. Photomicrograph of sample HC73 of Lithology 8 showing a spar filled area where Tetradium sp. corallites have been dissolved away.

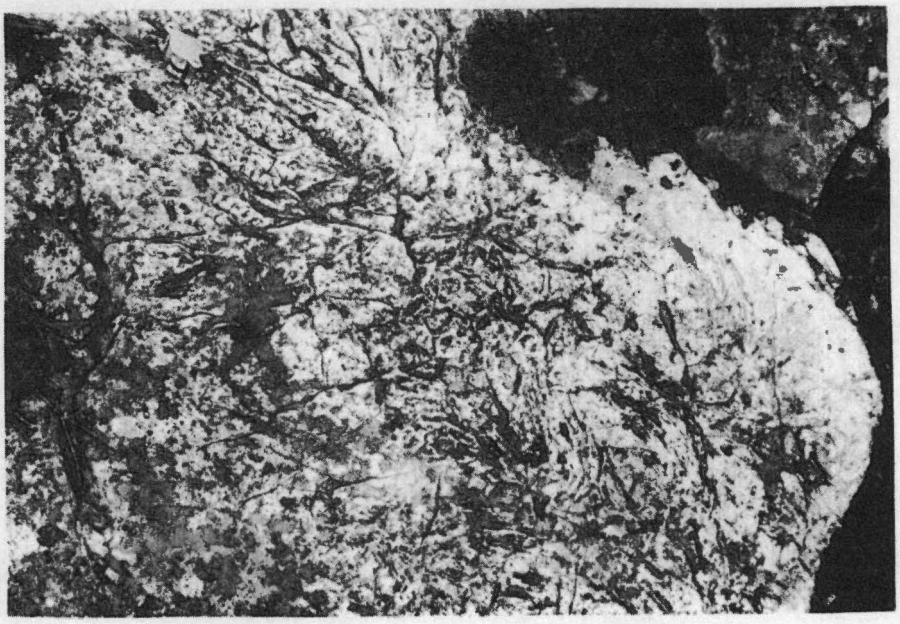

Figure 31. Photograph of Lithology 8 outcrop at Howard Cemetery section showing massive colony of Tetradium sp. in life position. Handlens in upper left is 4 cm long. The colony about .5 meters across.

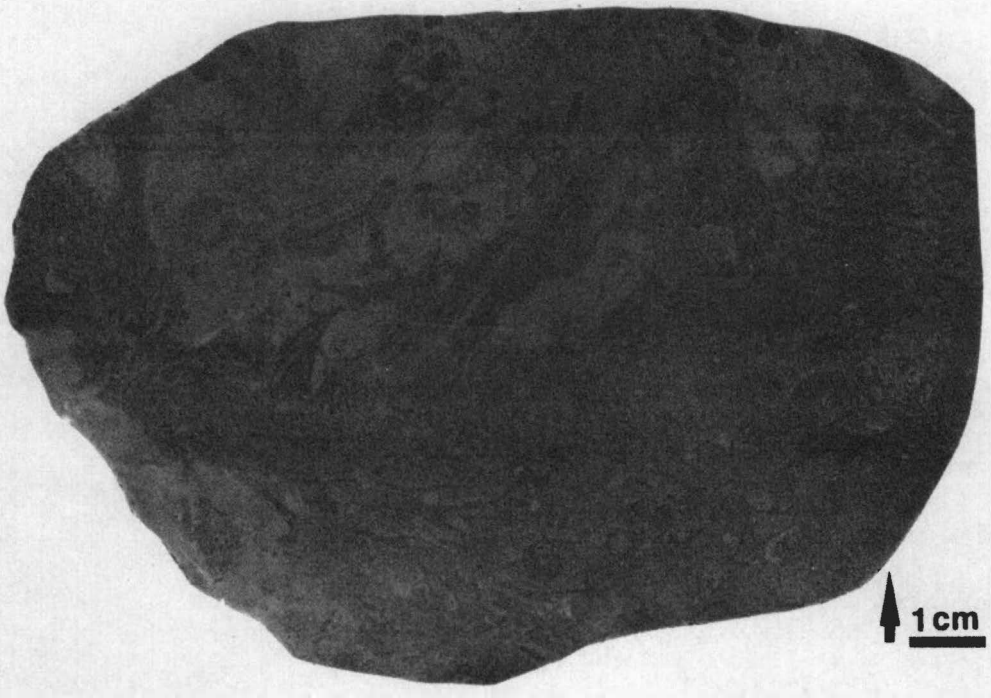

Figure 32. Negative print of a peel of sample P 75 showing Tetradium sp. in life position. Actual size of sample.

valves, and ostracod valves. Some of the fossils are filled with sparry calcite and others notably gastropods and brachipods, are geopetally filled with calcite and micrite. Mottling in the micrite probably is related to solution. A few dolomite rhombs are observed to be associated with reddish brown stains. Overlying the Tetradium colonies are fragmented fallen coralla of the coral along with debris from several fossil groups including bryozoans, trilobites, ostracods, gastropods and rugose corals. Intraclasts are also present in this fossil debris. The change from Tetradium in living position to the overlying lithology can be seen in Figure 33. Note particularly the rapid transition upward from the micrite surrounded coralla of Tetradium to the debris of fossils and intraclasts above a marked horizon in the sample.

Environmental Interpretation of Lithology 8

The depositional environment for lithology 8 is similar to that suggested for a Black River lithology by Walker (1973) his "Tetradium wave-baffle and wave-baffle margin." The dense intergrowth of Tetradium colonies probably sheltered adjacent areas and also contributed depositional material in the form of fallen coralla. The colonies probably slowed currents and waves causing fine sediment to be deposited about them.

The Tetradium colonies probably represent shallow subtidal with the underlying lithology representing a shoreward facies. The presence of solution and collapse previously mentioned may also be indicative

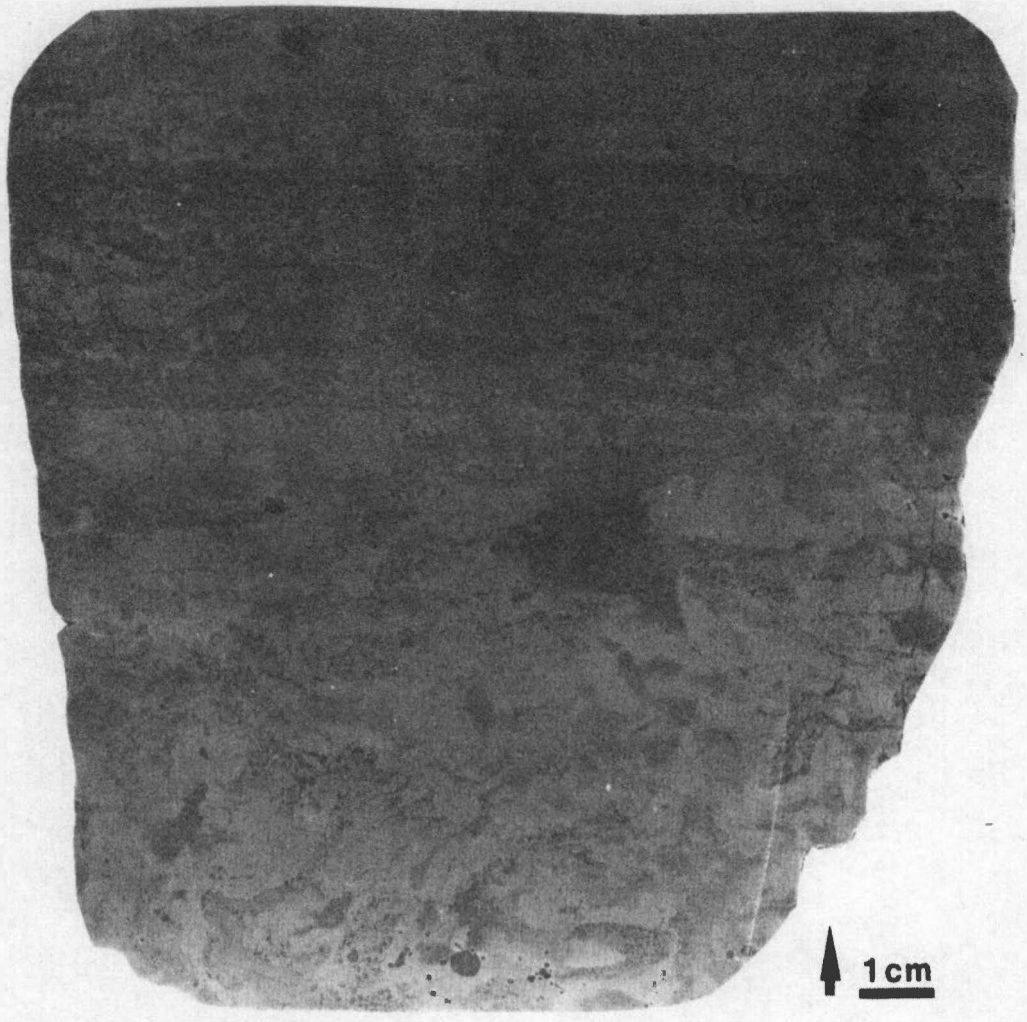

Figure 33. Negative print of a peel of sample B 63, Lithology 8, showing micrite surrounded coralia of Tetradium sp. in the bottom two-thirds. Above a marked horizon, debris of tetradium and several other fossil taxa may be observed. Actual size of sample.

of evaporite conditions in a sheltered area. The formation of some of the more or less semicircular cracks now spar-filled may have resulted from solution of more soluble evaporite minerals. However, no imprints of crystals of such minerals were noted. The predominance of vertical burrows is regarded by Laporte (1971) as evidence of shallow subtidal or tidal flat conditions. Walker (1973) places vertical burrows as predominantly intertidal. The presence of vertical burrows and the shrinkage features in the shoreward facies of this lithology may indicate "short" periods of subaerial exposure. However, subtidal conditions are indicated in most of this lithology by the presence of a wide diversity of fossils and the high number of taxa represented (Laporte 1968). Tetradium sp. is the most abundant and dominates the depositional environment. Brachiopods (some articulated and spar-filled), pelmatozoans, bryozoans, gastropods, ostracods, trilobites, and rugose corals were also among the diverse fossil groups that played lesser roles in the environment.

Analysis of Lithology 14 as a Subunit of Lithology 8 and Environmental Interpretation

An occurrence of a lithology similar to lithology 14 described earlier as a subunit of lithology 7, occurs in the middle of lithology 8 in the Mill Branch section. It could possibly be a tidal delta as suggested for the lithology 7 occurrence or possibly a tidal channel with well sorted fine fossil fragments and pellets as the principal constituents.

Analysis of Lithology 16

This lithology overlies lithology 8 at the Howard Cemetery section and lithology 7 at the McWilliams Creek section as a thin unit that is principally a pelsparite. The pellets are in the 100 to 200 micron range, are mostly opaque and appear to be clumped together into grapestone grains (see Illing, 1954). Laminae are observed in lithology 16 and in some areas interlaminar calcite is present along with birdseyes 0.5 to 8 millimeters across in some samples. Rare dolomite rhombs were observed. Widely scattered fossils consisting of ostracod valves, brachiopod valves, and trilobite debris were noted. Mudcracks with 1 inch polygons are also present. Horizontal and vertical mottling possibly represent burrows. The horizontal ones are filled with pellets partially replaced by dolomite rhombs. Micrite intraclasts were observed in one sample.

Environmental Interpretation of Lithology 16

Lithology 16 is assigned to the intertidal depositional environment and is probably time equivalent to lithology 8. No Tetradium was observed in these rocks, however. Only a few fossils were observed in this lithology and those were limited to three fossil groups. Subaerial exposure and desiccation are evidenced by the presence of mudcracks, interlaminar calcite and birdseyes. All of these seem to confirm intertidal conditions at the time of deposition.

Analysis of Lithology 9

The microscopic analysis of thin-sections and peels of lithology 9 show that it consists of three basic lithologies. They are micrite with rare to common angular to prismatic indistinguishable fossil fragments in the 50 to 100 micron size range. The second lithology is biomicrite with abundant fossil fragments consisting of 50 micron to 3 or 4 millimeter diameter pelmatozoan ossicles, brachiopod valves, trilobites, ostracods, bryozoans, gastropods, rugose corals, algal debris and possible pelecypods. The third is a biopelsparite found in concentrations where pellets about 100 microns in diameter are associated with fossil fragments from about the same size to 200 microns.

Large fossils and abraded fragments of fossils are found in all three basic lithic types (see Figure 34A). Spar-filled gastropods are several millimeters across and bryozoan fragments measure a centimeter across. The material identified as micrite in the thin-sections may very well consist of closely compacted pellets. In some areas where microspar is present, in small amounts, outlines of pellets are definately suggested.

Mottling suggestive of burrows is noted in the micrite, (see Figure 34B and C). For the most part, the burrows are vertical, approximately 3 to 5 millimeters wide, and near the boundaries fossil fragments become more vertically oriented. Some of the burrows are horizontal, some diagonal. Pellets are found in many of the vertical mottles along with sparry calcite. Lenses of biomicrite, .5 to 1 centimeter in

Figure 34

Lithology 9

A. Negative print (actual size) of peel of sample L-71, which shows fossil fragments both in a pelsparite matrix (dark area) and pelmicrite and micrite matrix (light area).

B. Negative print (actual size) of peel of sample L-65 which shows burrow mottling, mostly vertical, and lenses of biomicrite .5 to 1 cm thick in lower right corner.

C. Negative print (actual size) of peel of sample P-83 shows principally pelmicrite and micrite types with vertical mottling suggestive of burrows.

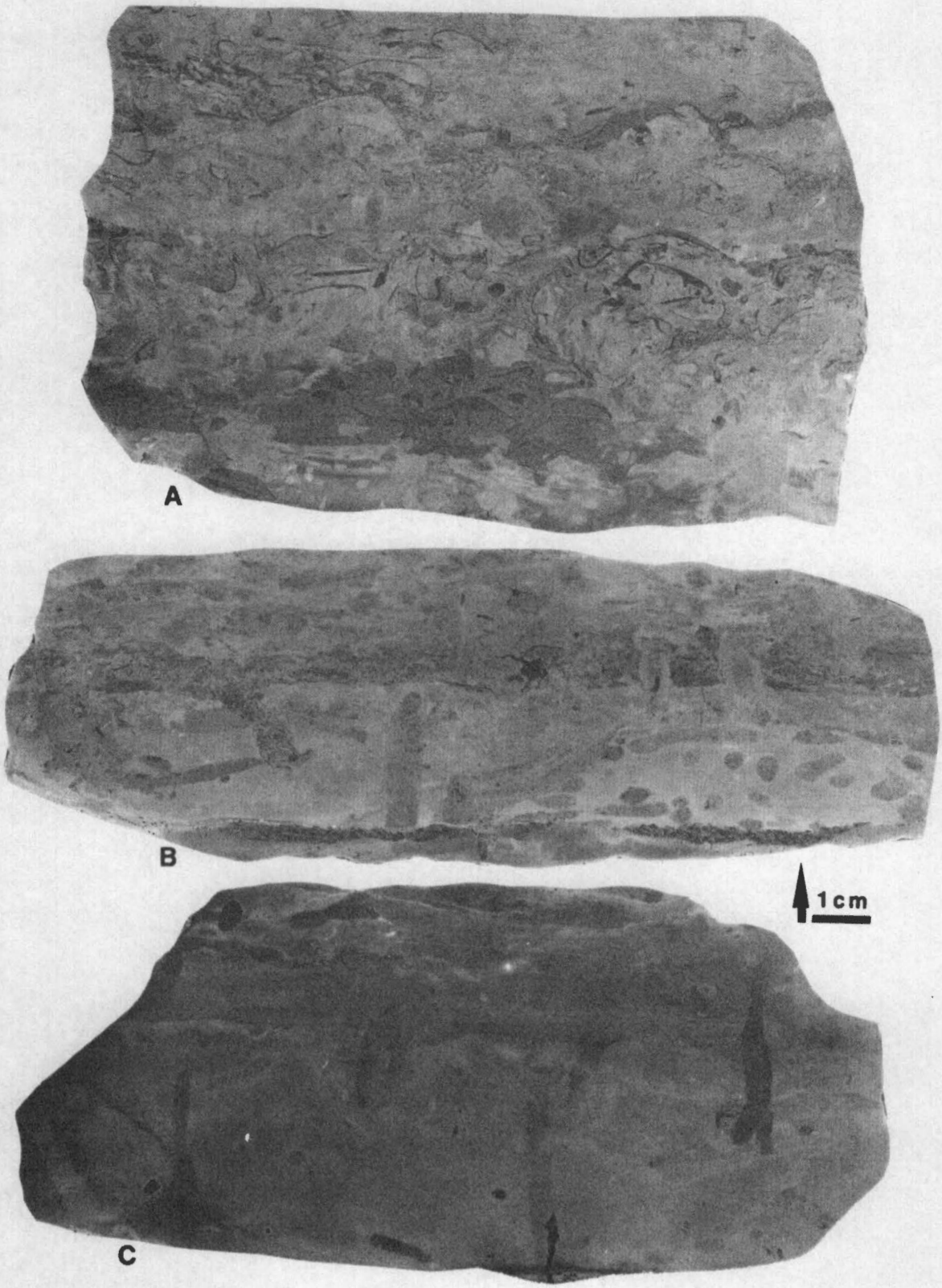

Figure 34. Lithology 9

thickness, with 50 to 100 micron fragments of unidentifiable fossil debris are found within the micrite lithic type as shown in Figure 34B and Figure 35. The boundaries between the two lithic types are very sharp. There is evidence of scour and subsequent fill by fossil fragments along some of the top of beds. Intraclasts of micrite are found concentrated with fossil debris. They are angular to rounded and one intraclast shown in Figure 36 is extraordinary. It is 5 centimeters long and 2 millimeters thick. Others are smaller, more rounded, and more equidimensional. Vertical spar-filled areas are possible mudcracks. Laminations which have interlamina spar in places are also present.

In the Howard Cemetery and McWilliams Creek sections where portions of Lithology 9 underlie the T-4 bentonite, some areas have been replaced by silica.

Environmental Interpretation of Lithology 9

The depositional environment proposed for this sequence is varied. Desiccation features such as the mud cracks, birdseyes, interlamina calcite, and intraclastic zones in some beds suggest the intertidal zone. On the other hand, both vertical and horizontal burrows suggest subtidal (Laporte, 1971). The wide variety of fossil taxa, some individual brachiopods being articulated and filled with spar, also suggest subtidal conditions. The characteristics of this lithic unit vary geographically. Where the unit is thinnest in the northeast lithology 9 has more subtidal characteristics. In the southwest portion of the area the part of the unit just below and just above

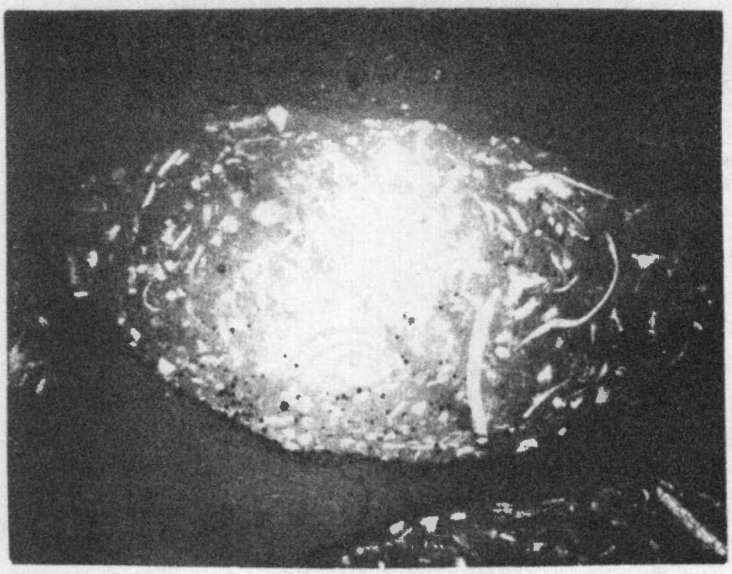

Figure 35. Photomicrograph of sample L 65 showing lense of biomicrite within a micrite. Notice the sharp boundaries between the 2 lithic types.

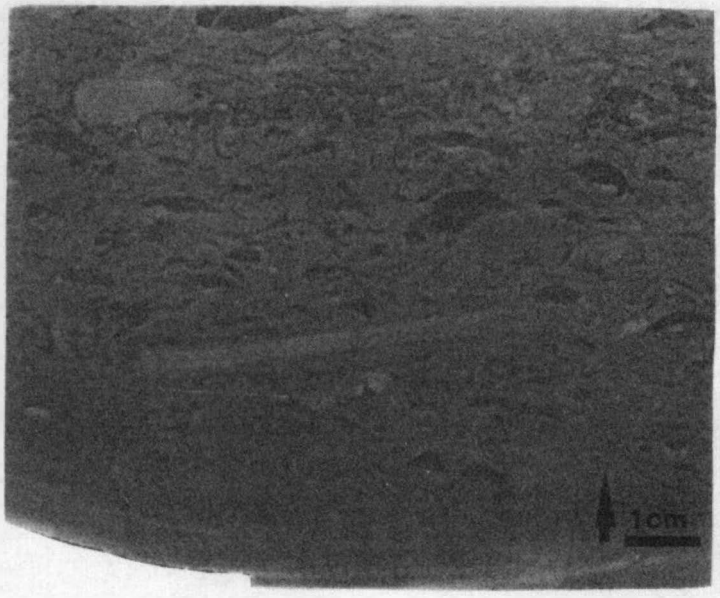

Figure 36. Negative print of peel of sample HC82 showing intraclastic biomicrite and biosparite. Note the elongate intraclast in the center of the print which has the same lithology as the layer at the base of the print. Actual size of sample.

the T-4 bentonite are subtidal but tend to have more intertidal characteristics higher in the units. Intertidal characteristics such as desiccation features, laminations, and intraclastic zones. Therefore, a shallow subtidal, low intertidal environment of deposition is assigned to lithology 9.

Analysis of Lithology 10

Study of lithology 10 peels and thin-sections show two basic lithic types that grade into each other on all scales vertically and laterally. The most abundant lithic type is biosparite (lithology 10A in Chapter II). It consists of fossils which range in size from 50-60 microns to 2 centimeters. They are from several groups, fragmented, abraded and some are algally bored. The groups identified are crinoids, brachiopods, bryozoans, trilobites, ostracods, pelecypods, gastropods, and rugose corals. The crinoids are the most abundant. Many of the crinoid plates show internal crystallization or recrystallization to dolomite which is not stained by alizarin red-s. In some of the thin-sections and peels are concentrations of what appear to be broken and rounded fragments of these dolomitized crinoid plates. The spaces between fossils and occasional intraclasts are filled with sparry calcite. Up to 65 percent of one sample consists of sparry calcite. Dolomite rhombs are present in zones apparently stained by solution of fossils. Typical biosparite lithic type is shown in is shown in Figure 37A and and the top of Figure 37C.

The other lithic type, referred to as lithology 10B in Chapter II is a biomicrite. Figure 37B shows the typical biomicrite. The

Figure 37

Lithology 10

A. Negative print (actual size) of peel of sample L-77 of lithology 10 showing the typical biosparite.

B. Negative print (actual size) of peel of sample L-79 of lithology 10 showing typical biomicrite.

C. Negative print (actual size) of peel of sample P-90 showing contact between lithology 10 biomicrite on bottom and biosparite at the top.

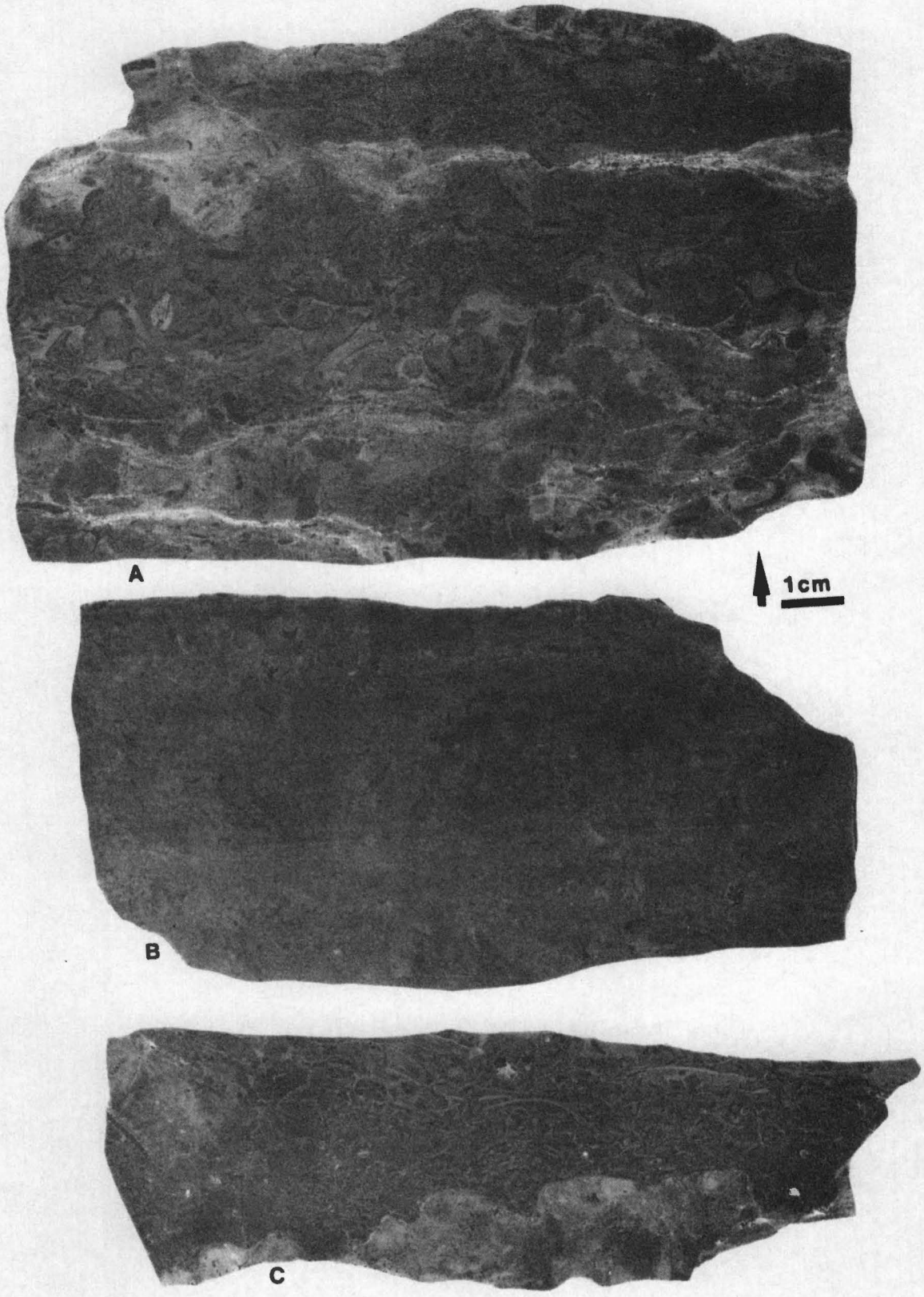

Figure 37. Lithology 10

micrite matrix has an abundance of fossil debris which ranges in size from less than 100 microns to 8 millimeters. The fossils present are crinoid ossicles which out number the brachiopod, bryozoan, trilobite, ostracod and gastropod debris which constitute the remainder of the fossil material. Some intraclasts are observed in this lithic type. A contact between the two lithic types in lithology 10 is shown in Figure 37C.

Environmental Interpretation of Lithology 10

The environment of deposition for lithology 10 is considered to be shallow subtidal. The abundance of fossils from several taxa show signs of high energy. The fossil grains are abraded and greatly fragmented. The fossils show few signs of being in living position. An exception may be articulated brachiopods filled with sparry calcite. The fossils have a jumbled appearance, owing to probable bioturbation by burrowers.

CHAPTER IV

SUMMARY AND CONCLUSIONS

General

The environments of deposition inferred for the rocks of the study area when compared to the model proposed by Walker and Alberstadt (1973) have many similarities. Figure 38 is a cross sectional representation of their concept of regional environmental conditions prevailing during deposition of Middle Ordovician carbonate sediment from the Central Basin to East Tennessee. The basic model has a bryozoan/pelmatozoan reef tract bounding the southeast edge of a carbonate bank (details of the reef tract are reported in Walker and Ferrigno, 1973; Ferrigno and Walker, 1973; and Ferrigno, 1973). A backreef lagoon was located northwest of the reef tract (reported by Ratliff, 1974, and Stephenson, Walker, and Moore, 1973). A complex carbonate bank was located further west which consisted of intertidal supratidal islands, channels, subtidal flats, etc. (Milici and Walker, 1973). A basin receiving terrigenous clastics was southeast of the carbonate generating environment. The terrigenous clastics eventually filled the basin and were then deposited northwestward over the reef tract onto the carbonate bank. Fine clastics were distributed by currents on the bank and deposited with carbonate sediments.

The area of study falls within the complex carbonate bank portion of the model as indicated in Figure 38. Figure 39 shows a generalized

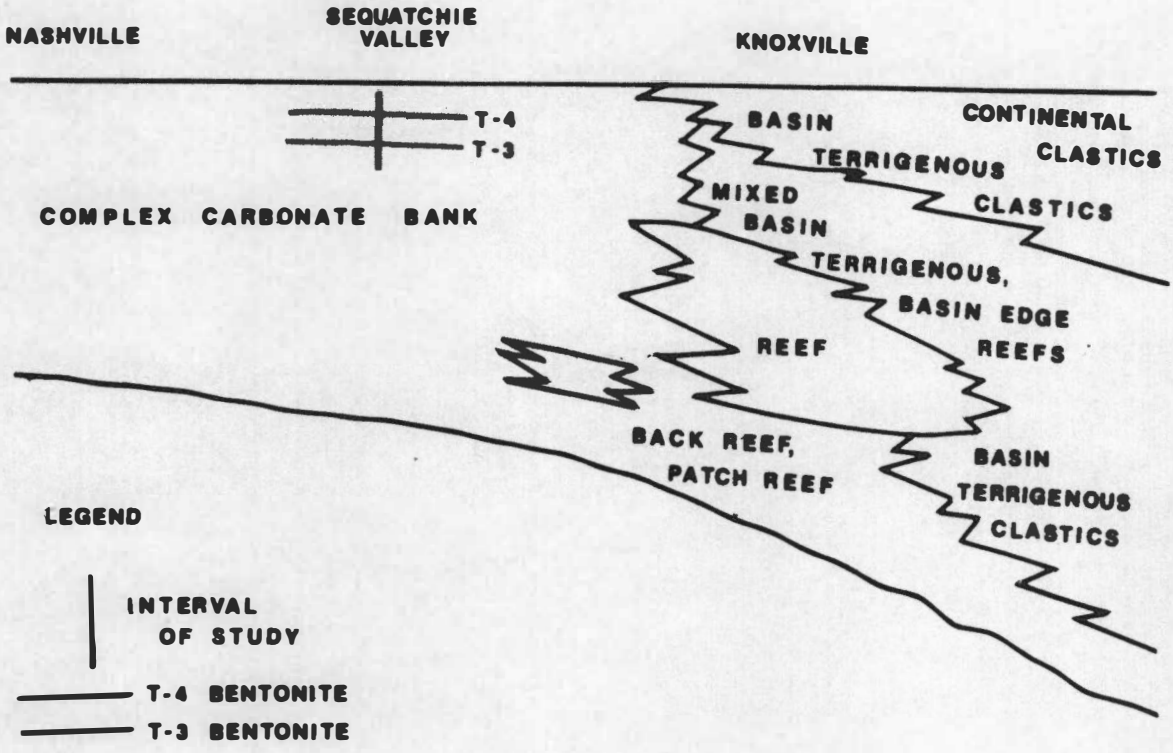

Figure 38. Complex carbonate bank to reef to basin facies pattern in the Middle Ordovician rocks of Tennessee which emerges when preliminary environmental, stratigraphic and sedimentologic data are considered. Refer to the text for a discussion of the placement of the interval of study (see Walker and Alberstadt, 1973).

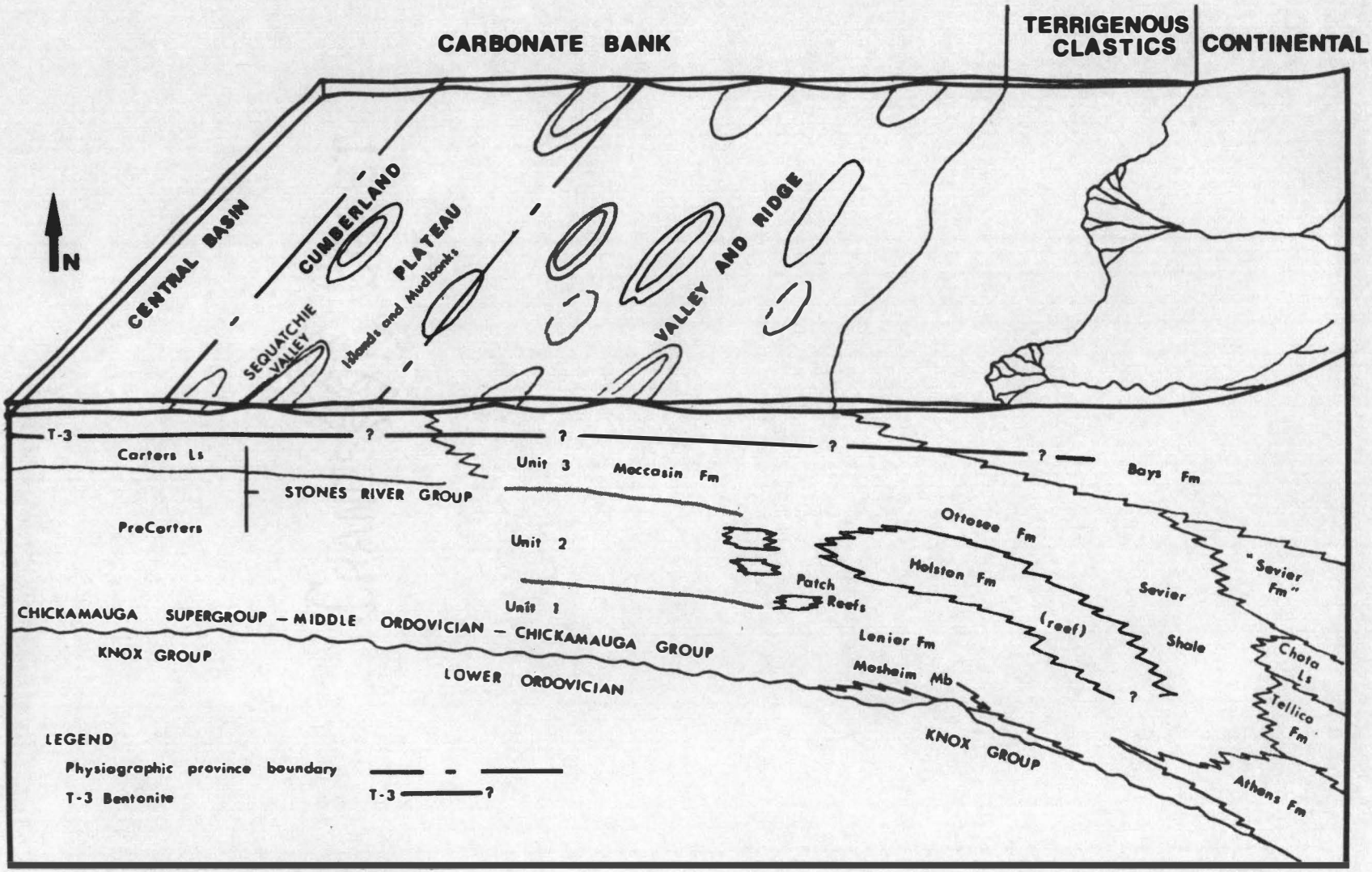

Figure 39. Block diagram of Central Basin to East Tennessee during Late Wilderness Age (Cooper 1956) showing contemporaneous environments, generalized facies relationships of strata in cross-section, and the present physiographic provinces. The area of study is in Sequatchie Valley part of the Cumberland Plateau (cross section modified after Walker, 1974).

block diagram of the author's concept of the model of Walker and Alberstadt (1973) (also see Walker, 1974), for contemporaneous environments on the bank at the time of deposition of the rocks of the study area.

The stratigraphic location of the area of study in Figures 38 and 39 with relation to the stratigraphic units to the east is problematical due to the uncertainties about age equivalence. Walker and Ferrigno (1973) report from their preliminary study of Bryozoa that the top of the Holston Formation (reef) is younger than had been suspected by previous workers who had regarded the Holston as varying in age from late Chazyan to late Porterfieldian. Walker and Ferrigno place it in late Wilderness which would make the Holston possibly equivalent to parts of the Carters of the study area (Cooper, 1956). Bergström (1973) through conodont and graptolite based correlation has revised the age of the Lenoir to include a longer span than proposed by Cooper (1956) and shows it to be younger in its westernmost occurrences. Bergström (1973) also extends the Sevier over a longer time range. Based upon correlation of bentonites in East Tennessee by Rodgers (1953) and other workers the T-3 and T-4 bentonites in the Carters Limestone are also found within the Moccasin and Bays farther east. The foregoing age relationships have been taken into consideration in construction of the diagrammatic cross sections in Figure 38 and 39.

The terrigenous influence, greatest in the Bays seems to diminish in influence to the west. Clay present in many of the lithologies in the study area may have originated in the same source area as clastics in the Moccasin and Bays formations.

Depositional History of the Study Area

The author assumes the Walterian concept while developing the environmental succession in the area of study. The concept that there is a lateral array of justaposed depositional environments represented vertically in a sequence of strata.

The depositional surface within the area of study probably had a low gradient such as the present day carbonate environments of the Great Bahama Banks, Florida Bay, and Persian Gulf. With such low gradients it is felt that vertical distribution of environments in the study area may extend for great distances laterally and therefore regional inferences might be made. Figure 40 is a diagrammatic sketch of the distribution of depositional environments in the study area. The first phase of the depositional history in the study area involved marine waters deep enough so that wave action did not affect the quiet bottom sediments which were inhabited by an extensive epifauna and infauna. Occasional storm waves or tide generated currents did affect the bottom causing them to be winnowed of the fine fraction leaving concentrations of fossil fragments. The muds were probably then moved landward to be deposited or intertidal flats in circumstances similar to those reported by Ball, Shinn, and Stockman (1967) when hurricane Donna churned up offshore subtidal bottom sediments, along the South Florida coast putting them in suspension, and then winds caused the mud ladened waters to flood adjacent tidal flats where the mud was subsequently deposited. Some of the fossil concentrations may be

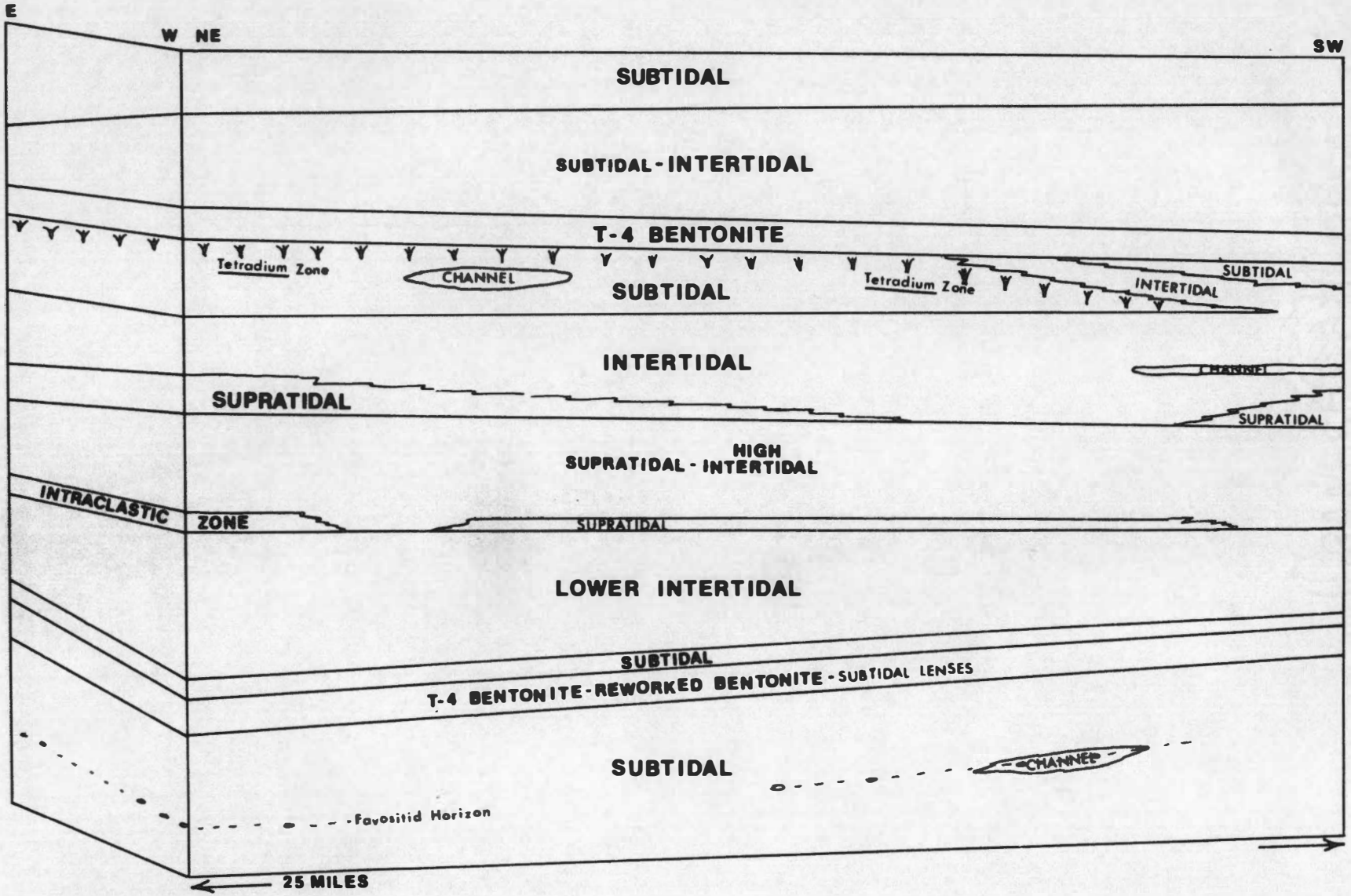

Figure 40. Diagrammatic sketch of the distribution of depositional environments in the study area. Refer to Figure 2.

tidal deltas formed at mouths of channels similar to those noted by Shinn, Lloyd, and Ginsburg (1969) near Andros Island tidal flats.

The marine waters may have become more shallow as evidenced by increased frequency of fossil debris concentrations. Perhaps placing the environments nearer wave base, nearer mean low tide, and/or nearer to adjacent tidal flats where channels might be more abundant.

Volcanic eruptions, more than likely to the southeast, covered the bottom with several feet of ash possibly changing the environment to supratidal or intertidal and probably killing much of the fauna and flora. Organisms established themselves in patches on top of the in situ ash and ash reworked by currents. Finally the organisms inhabited the bottom throughout the area in what must have been shallow turbulent waters as evidenced by relatively micrite free fossil debris with valves of pelecypods jumbled and nested.

The depositional environment that followed throughout the study area, appears to have been just above mean low tide because features in the sediment seem to indicate a low intertidal environment. Successive deposits seem to have become more shallow thus allowing for longer periods of subaerial exposure until the area appears to have been emergent for extended periods. The periods were finally long enough for dolomite to form as a large proportion of the sediment but with the sediment still possessing some intertidal characteristics. In the northern part of the area of study and particularly to the northwest the rocks bear strong evidence of continuous emergence. To the south these rocks thin

and are not present in the Howard Cemetery section. Farther south, however, at the same stratigraphic position, rocks high in clay content bearing supratidal characteristics are present. These supratidal environments grade laterally into an intertidal (tidalflat) environment which is judged to have been nearer mean sea level than the previously mentioned intertidal episode. The supratidal environments grading laterally into an intertidal environment probably represent islands or mudbanks on a tidal flat. The intertidal influence increases until the entire area is covered by intertidal sediments. The intertidal environment (tidal flat) was crossed by tidal channels as evidenced by concentrations of well sorted and cross-laminated fossil debris. The establishment of this intertidal environment near mean sea level seems to be the start of a transgressive phase in the study area. The marine waters apparently deepened in most of the area allowing the establishment of a varied epifauna and an infauna of burrowers. In the Howard Cemetery section Tetradium, sp in life position is observed and is thought to be older here than elsewhere in this subtidal environment to the north. The environment does not continue to the south. It grades laterally into an intertidal depositional environment which may represent a mudbank exposed within the subtidal zone only during tidal fluctuations (Milici and Walker, 1973). A Tetradium sp biostrome seems well established in the north portion of the study area. The Tetradium in life position may have had landward and seaward facies as evidenced by the abundance of fragmented Tetradium found in beds above and below. Evidence that tidal channels crossed this

environment is shown in concentrations of well sorted, cross-laminated fossil debris.

Another episode of volcanic activity occurred to the east or southeast resulting in a blanket of several feet of volcanic ash over the area. The ash fell on to Tetradium bearing beds in the northern portion of the area into an intertidal environment farther south and in the southern most portion of the area fell into a environment found above the bentonite to the north.

Above the ash fall, subtidal deposits are mixed with possible low intertidal deposits. These deposits are progressively thicker to the south and east where more intertidal influence seems to prevail. The next environment is considered to be subtidal with an abundance of organic activity. The presence of dominant crinoid ossicles in the rocks suggest an environment something like a "crinoid meadow" probably occupying shallow water. Shallow water is suggested because of the indications of high energy in the disordered arrangment of fossils, their extensive abrasion, the lack of finer material in most of the environment, and micrite envelopes in some fragments attributable to algae.

Conclusions

Depositional strike in the area of study is probably very close to structural strike which trends northeast-southwest. This conclusion is reached owing to the parallelism between the bentonite layers and the contacts between environments within the area of study. It is felt

that more time transgression of beds within the time framework (bentonite layers) might be noted if the line of sections cut across depositional strike.

The vertical sequence of depositional environments discussed probably reflects a regression of the Medial Ordovician sea leaving much of the area subaerially exposed for protracted intervals as islands and mudbanks with intervening intertidal flats. Subsequent to the subaerial exposure marine waters returned in a transgressive phase across the carbonate bank of very low gradient.

Returning with the marine waters were carbonate sediment generating faunas. Shinn and others (1969) caution against the use of fluctuating sealevel as a cause for regressive or transgressive minor sequences in ancient rocks. They have observed regressive sedimentary conditions on the southwest coast of Andros Island where supratidal flats appear to be migrating seaward. Similar conditions have also been reported by Kinsman (1964) for tidal flats along the Trucial Coast of the Persian Gulf. Shinn and others (1969) suggest that rate of sediment supply and exposure to wave action may be the controlling factors in determining regressive and transgressive tidal flat sedimentation. Changes in conditions on the bank may have been related to several factors or a combination of factors as follows:

1. Wide spread volcanic ash falls may have contributed to more shallow conditions on the bank. The ash may have caused "instant" suptratidal conditions that complicated the environment during subsequent deposition.

2. Differential subsidence on the bank and in the basin to the southeast could cause fluctuations in the water level within the study area.
3. Uplift in the Central basin area. Evidence of this is the possible truncation by erosion of the Upper Carters Member across the Central Basin (Wilson 1949, 1962) or more likely non-deposition of T-4 bentonite bearing strata in the Central Basin due to the emergence of a large area of the carbonate bank.
4. Migration of mudbanks and islands within the local environment of the study area caused by currents and wave action affecting the distribution of land and sea.
5. Eustatic sea level changes.

The environments of deposition prevailing during the Ordovician must have been very similar to some of the carbonate environments today. The wide, shallow, and clear water carbonate environments of the Great Bahama Bank, Florida Bay, and Persian Gulf all have characteristics that lend themselves as modern analogues of depositional environmental characteristics observed in the portions of the Carters and Hermitage formations that constitute the basis of this report.

SELECTED REFERENCES

SELECTED REFERENCES

Alberstadt, L. P., 1973, Depositional environment and origin of the fine-grained limestones of the Bigby-Cannon Formation (Middle Ordovician), Central Basin, Tennessee: Jour. Sed. Petrology, v. 43, p. 621-633.

Anderson, J. J. and Everett, J. R., 1965, Mudcrack formation studied by time lapse photography (abst.) in Abstracts for 1964, Geol. Soc. Amer. Spec. Pap 82, p. 45.

Ball, M. M., 1967, Carbonate Sandbodies of Florida and the Bahamas, J. Sed. Pet. 38, p. 556-591.

Ball, M. M., Shinn, E. A., and Stockman, K. W., 1967, Geologic effects of Hurricane Donna in South Florida: Jour. of Geol, v. 75, p. 583-597.

Bassler, R. S., 1932, The Stratigraphy of the Central Basin of Tennessee. Tenn. Div. Geol. Bull. 38, 183p.

Bathurst, R. G. C., 1958, Diagenetic fabrics in some Dinatian limestones: Liverpool and Manchester Geol. Journal, v. 5, p. 11-36.

Bathurst, R. G. C., 1971 Carbonate sediments and their diagensis: Elseiver Pub. Co., Amsterdam, New York, 620 p.

Bergström, Stig M., 1973, Biostratigraphy and Facies Relations in the Lower Middle Ordovician of Easternmost Tennessee. American Journal of Science, Cooper vol. 273-A, p. 261-293.

Cooper, G. A., 1956, Chazyan and related brachiopods: Smithsonian Inst. Misc. Coll. Pt. I, 1024 p.

Dunham, R. J., 1962, Classification of carbonate rocks according to depositional textures, in Classification of Carbonate rocks (Hamm, ed.): Amer. Assoc. Petroleum Geol., Mem. 1, p. 108-121.

Fåhraeus, L. E., et al., 1974, origin of carbonate pseudopellets, Jour. Sed. Petrology, v. 44, no. 1, p. 27-29.

Fenneman, N. M., 1938, Physiography of Eastern U.S. McGraw-Hill Book Co. 350 p.

Ferrigno, K. F., 1973, Paleoecology of the reefs of the Holston Limestone: Unpub. Doctoral Dissertation, Univ. of Tennessee, 142 p.

Ferrigno, K. F. and Walker, K. R., 1973, Ectoproct (Bryozon) communities in the Middle Ordovician Holston reefs in Tennessee (abst.): Geol. Soc. Amer. Southeast Ann. Meeting, (Program with Abst.), p. 396.

Ferrigno, K. F., and Walker, K. R., 1973, Holston Formation and Chapman Ridge Formation-Bryozoan reefs, flanking pelmatozoan calcarenites, and terrigenous silt and sand-flats, at Chapman Ridge, Knox County, Tennessee. Tenn. Div. Geol Bul 70, p. 117-121.

Fisher, Donald W., 1962, Correlation of the Ordovician Rocks in New York State, New York State Museum and Science Service Geological Survey, Map and Chart Series: No 3, 1p.

Folk, R. L., 1959, Practical classification of limestones: Amer. Assoc. Petroleum Geologists. Bull., v. 43, p. 1-30.

Folk, R. L., 1962, Spectral subdivision of limestone types, in Classification of carbonate rocks (Hamm, W., ed.): Amer. Assoc. Petroleum Geol., Mem. 1, p. 62-84.

Folk, R. L., 1965, Some aspects of recrystallization in ancient limestones in Dolomitization and Limestone Diagenesis, A Symposium (Murray, R. C. and Pray, L. C., eds.): Soc. Econ. Paleon. and Mineralologists, Spec. Publ. no. 13, p. 14-48.

Gebelein, C. D., 1967, Origin and growth rate of subtidal algal stromatolites, Bermuda (Abst), Geol. Soc. Amer. Ann. Mtg., New Orleans, p. 75-76.

Ginsburg, R. N., Isham, L. B. Bein, S. J., and Kuperburg, J., 1954, Laminated algal sediments of South Florida and their recognition in the fossil record. Univ. Miami Mar. Lab., unpub. rept. 54-21 p. 1-33.

Ginsburg, R. N., 1956, Environmental relationships of grain size and constituent particles in some south Florida carbonate sediments: Amer. Assoc. Petroleum Geol. Bull., v. 40, p. 2384-2427.

Goldburg, M., 1967, Supratidal dolomitization and dedolomitization in Jurassic rocks of Hamakhtesh Haqatan, Israel: Jour. Sed. Petrology, v. 37, p. 760-773.

Hayes, C. W., 1894. Geologic Atlas U.S., Chattanooga, Tennessee, Folio 6, U.S. Geol. Survey.

Hayes, C. W., 1895, Geologic Atlas U.S., Pikeville, Tennessee, Folio 21, U.S. Geol. Survey.

Hayes, C. W. and Ulrich, E. O., 1903, U.S. Geol. Atlas, Columbia Polio No. 95, U.S. Geological Survey.

Illing, L. V., 1954, Bahaman calcareous sands. Amer. Assoc. Petrol. Geol Bull., 38, p. 1-95.

Ingram, R. L., 1954, Terminology for the thickness of stratification and parting units in sedimentary rocks: Geol. Soc. Amer. Bull., v. 65, p. 937-938.

Irwin, M. L., 1965, General theory of epeiric clear water sedimentation, Assoc Petrol. Geol Bull 49 No. 4 p. 445-459.

Kinsman, D. J. J., 1964, Recent carbonate sedimentation near Abu Dhabi, Tricial Coast, Persian Gulf: Ph.D. thesis, Department of Geology, Imperial College, London, 302 p.

Laporte, L. F., 1967, Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius Formation (lower Devonian) of New York state: Amer. Assoc. Petroleum Geol. Bull., v. 51, p. 73-101.

Laporte, L. F., 1968, Recent carbonate environments and their paleoecologic implications in Evolution and Environment (Drake, E. T., ed.): Yale Univ. Press, New Haven, Conn., p. 229-258.

Laporte, L. F., 1969, Recognition of a transgressive carbonate sequence within an epeiric sea: Helderberg Group (lower Devonian) of New York State in Depositional Environments in Carbonate Rocks (Friedman, G. M., ed.): Soc. Econ. Paleo. and Mineralologists, Spec. Publ. 14, p. 98-114.

Laporte, L. F., 1971, Paleozoic carbonate facies of the Central Appalachian shelf, Jour of Sed Pet, vol 41, no 3, p. 724-740.

Logan, B. W., 1961, Cryptozoon and associated stromatolites from the Recent, Shark Bay, Western Australia, J. Geol v. 69, p. 517-533.

Matthews, R. K., 1966, Genesis of Recent lime and mud in southern British Honduras, Jour. of Sed. Pet. vol. 36, no 2, p. 428-454.

McLaughlin, R. E., 1973, Observation on the biostratigraphy and stratigraphy of Knox County, Tennessee and vicinity: Tenn. Div. Geol. Bull. 70, p. 25-62.

Milici, R. C. and Smith, J. W., 1969, The stratigraphy of the Chickamauga Supergroup in its type area: Georgia Geol. Surv. Bull. 80, p. I-35, and Tenn. Div. Geology Rept. Invs. no. 24.

Milici, R. C., Brent, W. B. and Walker, K. R., 1973, Depositional environments in Upper Conasauga lagoon-fill sequences along I-75 at Copper Ridge, Knox County, Tennessee: Tenn. Div. Geol. Bull. 70, p. 138-148.

Milici, R. C., 1970, Middle Ordovician Stratigraphy in central Sequatchie Valley, Tenn: Southeastern Geology, v. 11, no. 2 p. 111-127.

Purdy, E. G., 1963, Recent calcium carbonate facies of the Great Bahama Banks. 1. petrography and reaction groups, and 2. sedimentary facies: Jour. Geol., v. 71, p. 334-355 and 472-497.

Ratliff, L. E., 1974 Environmental stratigraphy of the middle Ordovician carbonates in the Luttrell, belt, Union and Grainger Counties, East Tennessee, unpubl. Doctoral Dissertation, University of Tennessee.

Rodgers, J., 1953, Geologic map of east Tennessee with explanatory text: State of Tenn., Dept. of Conserv., Div. of Geol., Bull. 58, pt. II, 168 p.

Safford, J. M., 1869, Geology of Tennessee: State of Tennessee, Nashville, 550 p.

Scoffin, T. P., 1970, The trapping and binding of subtidal carbonate sediments by marine vegetation in Bimini Lagoon , Bahamas. J. Sed. Pet. 40, p. 249-273.

Shinn, and Ginsburg, R. N., 1965, Recent supratidal dolomite from Andros Island, Bahamas in Dolomite and Limestone Diagenesis, A Symposium (Murray, R. C. and Pray, L. C., eds.): Soc. Econ. Paleon. and Mineralologists, Spec. Publ., no. 13, p. 112-123.

Shinn, E. A., 1968, Practical significance of birdseye structures in carbonate rocks, J. Sed. Pet vol. 38, p. 215-223.

Shinn, Eugene A., Michael Lloyd, and R. N. Ginsburg, 1969, Anatomy of a modern carbonate tidal-flat, Andros Island, Bahamas; Jour of Sed Pet, vol 39, no. 3, p. 1202-1228.

Stephenson, J. P., Walker, K. R., and McLaughlin, R. E., 1973, The Lenoir Formation - Back Reef Supratidal, Intertidal, and Subtidal Shelf lagoon facies; Tenn. Div. of Geology Bull. 70, p. 122-126.

Swingle, G. D., 1964 Elevation of the Chickamauga Limestone to group status in East Tennessee [abstract]: Tennessee Academy of Science Journal, vol. 39, no. 2, p. 66.

Twenhofel, W. H., Bridge, J. Cloud, P. E., Cooper, B. N., Cooper, G. A.,Cummings, E. R., Cullison, J. S., Dunbar, C. O., Kay, G. M., Liberty, B. A. McFarland, A. C., Rodgers, J. Whittington, H. B., Wilson, C. W., 1954, Correlation of the Ordovician Formations of North America: Bull. Geol. Soc. Amer., v. 65, p. 247-298.

Walker, K. R., 1968, The stratigraphy, environmental sedimentolody, and community ecology of the Middle Ordovician Black River Group of New York state: Yale Univ., New Haven, Conn., Unpubl. Doctoral Dissertation.

Walker, 1973, Stratigraphy and environmental sedimentlogy of the Middle Ordovician Black River Group in the type area, New York: New York State Museum and Sci. Serv., Geol. Surv. Bull. 419, p. 43.

Walker, K. R. and Albertstadt, L. P., 1973, A new facies hypothesis concerning the Middle Ordovician of the Southern Appalacians. [abst]. Geol. Soc. Amer. Southeastern Section Meeting, p. 447-448.

Walker, K. R., and Ferrigno, K. F., 1973, Major Middle Ordovician reef tract in east Tennessee: Amer. Jour. Science, Byron Cooper Memorial.

Walker, K. R., 1974, Community patterns: Middle Ordovician of Tennessee, chapter 9 of Principles of Benthic Community Analysis (notes for a short course) by Ziegler, A. M. and others, Division of Marine Geology and Geophysics Rosenstiel School of Marine and Atmosphere Science, The University of Miami, p. 9.1-9.9.

Wentworth, C. K., 1922, A scale of grade and class terms for clastic sediments: Jour. Geology, v. 30, no. 5, p. 377-392.

Wilson, A. O., 1970, Petrogenesis of parts of Black River Age strata of the Chickamauga Limestone, Etowah, and Dekalb Counties, Alabama; Unpubl. doctoral dissertation, Univ. North Carolina, 112 p.

Wilson, C. W., 1938, Dividing the Carters Limestone into upper and lower members. Proc. Geol. Soc. Amer. for 1937, p. 291.

Wilson, C. W., Jr. 1949, Pre-Chattanooga Stratigraphy in Central Tennessee. Tennessee Div. of Geol. Bull. 56, 407 p.

Wilson, C. W., 1962, Stratigraphy and geologic history of Middle Ordovician rocks on Central Tennessee, Tenn. Div. of Geol. Rept. of Inv. no. 15, p. 481-504.

APPENDIXES

APPENDIX A

APPENDIX A

DESCRIPTIONS OF MEASURED STRATIGRAPHIC SECTIONS

The descriptions of measured stratigraphic sections that follow are listed with the base of the section first and the top of the section last. Consequently, the oldest units will appear at the top of each page and youngest units at the bottom.

The Rock-Color chart distributed by the Geological Society of America (1951) was used in designating colors. The terminology for describing thickness of stratification and parting units in this report follows Ingram (1954).

The size of the individual grains in the carbonate rocks are referred to by the following conventions:

DESCRIPTION	GRAIN SIZE
coarse grained	Grains readily identifiable with the unaided eye (usually larger than 1 mm)
fine grained	Grains visible but generally not identifiable with the unaided eye (generally equivalent to about 1/16 to 1 mm)
very fine grained	Individual grains not clearly visible (generally smaller than 1/16 mm)

Mud crack polygons are referred to as small when they are less than two inches across and large when they are more than two inches.

The descriptions of lithologies in this appendix are of limestone unless otherwise specified.

LITTON SECTION

Melvine Quadrangle, Tennessee, 7.5 minute series topographic 110-NE (1956); Geologic GM110-NE, Milici and Coker (1967). See Figure 1, page 4, for location. The base of the section is about 2,500 feet northwest of Litton, in a roadcut on the east side of the road and extending a little more than 300 feet to the northwest. (Tennessee Coordinates 492,850N., 2,284,180E. to 493,380N., 2,284,100E.)

UPPER PORTION OF CARTERS LIMESTONE, LOWER MEMBER

Thickness		Description
Cum.	Interval	
1'	12"	Very fine grained to coarse grained, light olive gray (5Y6/1) to olive gray (5Y4/1), burrow mottled limestone. Abundant fossil fragments. Sample L-1
1'2"	2"	Covered
1'2 3/4"	3/4"	Coarse grained to very fine grained abundant fossil fragments, crinoid columnals, brachiopod, gastropods. Clear sparry calcite filling gastropods. Sample L-2
1'5 1/4"	2 1/2"	Medium gray (N5) to brownish gray (5YR4/1), white calcite apparently filling voids. Large areas about 3/4" across, possibly fossils or fossil fragments. Favistella or Favisites. Sample L-3
1'6 1/4"	1"	Very fine grained with irregular approximately horizontal line passing through unit, possibly algal mat. Have an appearance something like stylolites.
1'7 1/4"	1"	Coarse grained, some clear calcite about 2 mm across.

Thickness Cum.	Interval	
1'9 3/4"	2 1/2"	Very fine medium gray (N5) limestone with irregular lines and fine grained stringers diagonally across the interval.
1'11"	1 1/4"	Band of coarse grained, some white and clear sparry calcite, some 2 mm across, others smaller.
2'1/2"	1 1/2"	Very fine grained with fine grained sandy-looking irregular stringers, possibly burrows. Coarse grained at the top, some fossil fragments observed on weathering surface. Fine grained burrow fillings weathered out.
2'6 1/2"	6"	Brownish gray (5Y4/1) to medium dark gray (N-4), very fine grained with fine grained filling that appear to be burrows which are mostly horizontal. Four irregular horizontal grayish black (N2) separations run through this bed (look something like stylolites). Some coarse grained material consisting of fossil and fossil fragments, high spired gastropods, possibly brachiopods, and trilobites. Sample L-4
2'10 1/2"	4"	Coarse grained stringers consisting mainly of fossil fragments. More horizontal and some diagonal burrows filled with fine grained (pellets?). Sample L-4
3'4 1/2"	6"	Very fine grained medium gray to brownish gray with a few fossil fragments widely spread and irregular fine grained stringers of light to medium gray. Dark gray irregular parting overlain by coarse and very fine grained material. The coarse layer ranges laterally from 1 inch to 2 inches and gives way to very fine grained material. Followed by fine grained burrows with very fine grained matrix and scattered fossil fragments.
3'19"	4 1/2"	A mixture of lithologies found below.
3'11"	2"	Coarse grained fossil fragments. Brachiopods mostly with some clear calcite filling voids or fossils.
4'1"	1-2"	Elongate irregular chert nodules from round to elliptical shapes, close to olive black (5Y2/1) in color. They range from about 2 feet to 1 inch across and form a continuous band across the outcrop.
4'7"	6"	A rather continuous (sandy appearing) fine grained bed which is overlain by chert in most places. Contains not only some small chert but also rounded rock fragments and possibly trilobite fragments mixed in. On three sides of the overlying chert nodules there is a very fine grained matrix with occasional rounded fine grained patches.

Thickness		Description
Cum.	Interval	
4'7	1/2"	Coarse grained fossil fragments mixed with fine grained (sandy) material, brachiopod and possibly trilobites, maybe some ostracods. This is overlain by a fine grained layer that is fairly continuous.
5'1/2"	5"	Very fine grained brownish gray limestone with occasional fossil fragments with irregular (possibly algal mats) fine grained stringers which are circular to elliptical shaped.
5'2 1/2"	2"	Fine grained enclosing very fine grained (possibly) intraclasts. Also crinoid columnals replaced by calcite.
5'7"	4 1/2"	Very fine grained with about 15-20% fine grained burrow mottling primarily horizontal crossed by calcite filled vertical joints - more fine grained near top of interval.
5'10 1/2"	3 1/2"	Characterized by fine grained mottling, some vertical but predominantely horizontal. There are several brownish black to black partings which seem to be associated with the mottling. The very fine matrix is typically brownish gray with brownish black mottling.
6'3 1/2"	5"	Above a prominant separation. Fine grained mottling approaches 30% of the rock, quite a few vertical joints filled with clear sparry clacite.
6'6 1/2"	2-3"	Coarse to very fine grained with possible brachiopod and trilobite debris dispersed throughout. At top of this interval a 1/4 to 3/4 inch fine grained stringer is very prominant and fairly continuous across the outcrop.
7' 1/2"	6"	This interval is variable, one place it is coarse grained with fossils and vugs filled with calcite. Some fillings up to 2 to 3 mm, sometimes 4 mm. Some vugs are only partly filled with sparry calcite, some very fine grained intraclasts. The coarse grained material with fine grained mottling mostly horizontal about 1/2 inch wide, some vertical about 1/4 inch wide. Note on sample L-5 what seems to be solution associated with mottling and the stylolite-like surfaces with brownish black color.
Sample L-5		
7'8 1/4"	7 3/4"	Brownish gray with an overall fine grained texture with fine grained, light olive gray to olive gray mottling which weathers to yellowish gray. A few coarse fossils and fragments, brachiopods, some filled with sparry calcite, also silicified bryozoans.

Thickness Cum.	Interval	Description
7'9 3/4"	1 1/2"	Brownish gray, very fine grained with little light olive gray to olive gray, fine grained mottling and brownish black irregular lines (seem to be associated with fine grained mottling). Sample L-6
7'10 1/2"	3/4"	Very fine to fine grained, light olive gray with coarse fossil fragments scattered ostracods, trilobite, and brachiopod debris. Sample L-6
8'1/2"	2"	Very fine grained with considerably more fine grained mottling (burrows?). Walls of burrows have glossy brownish black coating (may be associated with solution, weathering, etc.) Near top the mottling is weathered to a yellowish gray color. Some chert brownish black with inclusions (?) of very fine grained limestone were observed, in these three intervals represented by sample L-6.
9'6 1/2"	18"	Brownish gray with very fine grained texture for the most part with fine grained burrow mottles that have boundaries of brownish black to black. This bed contains a considerable number of fossils. Several colonies of favasitid coral in life position are concentrated in a zone in the bottom to center portion of the interval. One colony measures 1 1/2 inch by 3 1/2 inches, another about 5 inches high and 11 inches wide, other fossils include bryozoans (large branching type about 3/4 inch across), crinoid columnal, some of which are horizontal in an articulated position. Brachiopods and fragments. In the center of this interval, in the vicinity of the coral colonies, coarse grained layers occur. Sample L-7: About 9" above base.
9'11"	4 1/2"	Pronounced break continuous across face of outcrop. Predominately very fine grained to fine grained, brownish gray limestone, some white sparry calcite patches or birdseyes (possibly filling or replacing fossils). Few fine grained, light olive gray mottles. Coarse grained lenses possibly fossil debris.
10'2"	3"	Layer coarse grained debris with fine grained to very fine grained matrix and fine grained stringers or mottles of light olive gray.
11'	10"	Very fine grained with fine grained burrow mottling more or less horizontal. A few brachiopods, crinoid columnals and vugs filled with sparry calcite.

Thickness Cum.	Interval	Description
12'3"	15"	Brownish gray combination of coarse and very fine grained material about 5 partings in this interval consisting of fine grained horizontal stringers. Fossils in relief on weathered surface include brachiopods and crinoid columnals. Chert nodules about 5 inches above base, about 1/4 to 1/2 inch thick, and 2 inches to 10 inches wide.
12'7"	4"	Very fine grained with some coarse grains, also fine grained mottling.
12'9"	2"	Coarse grained mixed with fine grained stringers.
12'10 1/4"	1 1/4"	Very fine grained with rare coarse grains, overlain by coarse grained fossil debris on an irregular surface.
13'1 1/4"	3"	Very fine grained with fine grained burrow mottling.
13'5 1/4"	4"	Mostly coarse fossil debris and brachiopods filled with clear and white sparry calcite.
13'8 1/4"	3"	Very fine grained with patches of clear and some white calcite.
13'9 3/4"	1 1/2"	Coarse grained fossil debris, mostly brachiopods, in a very fine grained matrix.
13'10 3/4"	1"	Prominant parting. Coarse grained fossil debris.
13'11 3/4"	1"	Fine grained mixed with coarse grained.
14'2 3/4"	3"	Very fine grained limestone.
14'3 3/4"	1"	Coarse grained debris with about 80% very fine grained matrix, overlain by a stringer of fine grained. Then debris intermixed with matrix.
14'9 3/4"	6"	Very fine grained with clear calcite patches scattered throughout, some coarse grained small scale lenses.
14'10 3/4"	1"	Very fine grained, with calcite patches pinching and swelling laterally.

Thickness Cum.	Interval	Description
15'3 3/4"	5"	Very coarse grained fossils and fossil debris on weathered surface, fragments and complete brachiopods, bryozoans, rugose corals, colony of coral. Also some chert about 1 foot from base, chert nodules rather even top surface and convex downward. Seems to be fragmented and mixed with fine grained burrows through nodules (??). Apparent cyclic deposition of alternating layers of coarse debris then very fine grained with burrow mottling. Sample L-8
15'10"	6 1/4"	Medium dark gray to brownish gray overall color. Coarse grained at the base and overlain by and alternating with very fine grained layers with calcite filled fossils. The coarse fraction consists of brachiopods, crinoid columnals, small to quite large (4 mm), bryozoan fragments.
15'11 1/4"	1 1/4"	Shale, yellowish gray to light olive gray filled with round to flat oval objects which have the appearance of bryozoans. They have no outside texture and are brownish gray inside. Some of them branch.
16'2 1/4"	3"	Brownish gray to medium dark gray, very fine grained limestone alternating with irregular thin shale (1/4 inch) partings which have more of the bryozoan-like objects, (could be very fine grained burrow fillings weathered out). Top of interval marked by wavy surface, possibly algal mats.
16'7"	4 3/4"	Coarse grained layer which varies in thickness along the outcrop. Overlain by brownish gray to medium dark gray, very fine grained texture with lenses and pods of coarse grained texture. Chert nodule about 2 inches high and 4 inches wide observed. Coarse fraction of interval consists of brachiopod debris, bryozoans, and gastropods. Sample L-9
16'10"	3"	Coarse grained with same fossils as mentioned in the interval below. Sample L-10
17'4"	5 3/4-6"	Medium dark gray to brownish gray limestone with a considerable amount of dark brownish black chert. The limestone is very fine grained with fine grained mottling and some not very thick lenses of coarse grained. The chert is concentrated in the top 3 inches to 4 inches of the bed and weathers to moderate brown to light brown. Some rounded to oval structures in the chert seem to be a little coarser grained material. Some inclaves in the chert appear to be unaltered limestone similar to the host. On the top surface of the chert some brachiopods and other fossil fragments are observed. Sample L-11

TOP OF CARTERS LIMESTONE, LOWER MEMBER

SUBSEQUENT UNITS ARE CARTERS LIMESTONE, UPPER MEMBER

Thickness		
Cum.	Interval	Description
19'1"	21"	Fairly fresh bentonite with drag folds with amplitude of about 6 inches to 8 inches. Color is pale blue-green (5BG7/2).
19'4"	3"	Yellowish gray, coarse grained limestone (lens) with brachiopods, or ostracods. White patches of calcite probable fossil filling. Some pale olive mottling particularly around fossils. Sample L-12
19'4 3/4"	1/2-3/4"	Layer of coarse limestone with planispiral gastropods and brachiopod fragments. Sample L-13
19'11"	6 1/4"	Pale yellowish-green (10GY7/2) to pale green with streaks of dusky yellow to moderate yellow "bentonite".
20'1 3/4"	2 3/4"	Alternating of shale and limestone and/or sandy limestone color yellowish gray to light olive gray, some fossils and fragments, possibly ostracods and/or brachiopods. Sample L-14 Sample L-15: 1/2" limestone, fine grained, light olive gray.
20'3"	1 1/4"	Medium dark gray to brownish gray with fossil fragments, possibly brachiopods and trilobites.
20'4"	1"	Brownish gray limestone with fossil fragments amounting to 40% of the rock has the coarse materials in a fine to very fine grained matrix. Sample L-16
20'4 3/4"	3/4"	Yellowish gray to light olive gray, very argillaceous limestone, some coarse fossil debris. Sample L-17
20'5 1/4"	1/2"	Shale, yellowish gray to light olive gray with dark stains.
20'6 1/2"	1 1/4"	Brownish gray, very fine grained limestone with patches of olive gray, fine grained mottling. Large coarse fossil fragments in very fine grained, possibly pelecypods or brachiopods. Sample L-18

Thickness Cum.	Interval	Description
20'8"	1 1/2"	Irregular bedding surface, argillaceous zone with fossil fragments at base. The fossil fragments are jumbled around. Some parts of the interval are composed of brownish gray, very fine grained limestone.
20'9"	1"	Alternating lamina of what appears to be olive green shale and then brownish gray, very fine grained limestone.
20'10 1/2"	1 1/2"	Fine grained, brownish gray limestone with some fossil fragments. Dark fragments appear to be ostracods, possibly brachiopods, or maybe pelecypods. Sample L-19
20'10 3/4"	1/4"	Shale, olive gray thinly laminated.
20'11 3/4"	1"	Light olive gray, very fine grained with coarse brachiopod or pelecypod disarticulated valves mostly convex upward and horizontal to bedding.
21'1 1/2"	1 3/4"	Olive gray to brownish gray, fine grained to very fine grained at the bottom with a few fossil fragments. Toward the top of the bed abundant fossils, some about 1/2 inch to 3/4 inch across. Calcite filling brachiopods, also pelecypod and ostracods. Bivalved fossils have interesting arrangement of nesting of smaller valves within larger valves. Sample L-20
21'2 1/2"	1"	Light olive gray, very fine grained with a few fossil fragments. Sample L-21
21'5"	2 1/2"	Brownish gray to olive gray, very fine grained limestone, large amount of clear and white calcite possibly filling fossils as several fragments are observed on the weathered surface. Sample L-21
21'5 3/4"	3/4"	Very fine grained with stringers of coarse grained. This approximately 5 inch interval weathers into equal area blocks or large polygons which may represent mudcracks. Many fossil brachiopods or pelecypods filled with calcite on weathered surface. Sample L-21
21'11 1/4"	5 1/2"	Olive gray slightly banded argillaceous limestone or dolomitic limestone. Small polygons on surface possibly mudcracked to a depth of 2 to 3 cm. in some places. Sample L-22

Thickness		Description
Cum.	Interval	
22'2 1/2"	3 1/4"	Shale, yellowish gray to light olive gray.
22'4 1/2"	2"	Laminated to thin bedded calcareous mudstone, possibly dolomitic with 1/4 inch shale break in the middle. Beds broken up by possibly mudcracks and weathered into small rounded polygons.
22'6 3/4"	2 1/4"	Calcareous mudstone. Very fine grained with mudcracks. Sample L-23
24'2 1/4"	19 1/2"	Laminated very fine to fine grained, medium dark to brownish gray, with olive gray dolomitic limestone or dolomite with birdseyes possibly filling desiccation cracks. Occasional patches of coarse material as the interval is traced laterally. Sample L-24: Mid 3" to 4".
26'3/4"	22 1/2"	Appears to be about the same as below. Olive gray, very fine grained texture with (calcite patches) birdseyes and possible laminations. Some coarse grained lenses with fine grained matrix. Possibly some fossil fragments but appears to be patches of clear calcite, may be interlamina birdseyes. Sample L-25: Top 6 1/2".
26'1 1/2"	3/4"	Limestone, olive gray, very fine to fine grained. Sample L-26
26'2 1/2"	1"	Olive gray, very fine grained, a few wavy dark lines within interval and stringers of coarse grained material in zone about 1/8" thick. Sample L-26
26'3"	1/2"	Shale, olive green (no silt).
26'4"	1"	Intraclasts of elongate pebbles of light olive gray argillaceous limestone, some of the intraclasts are rounded. Sample L-27
26'4 1/2"	1/2"	Fine grained, light olive gray stringers with olive gray intraclasts. A few calcite patches. Sample L-27
26'6 1/2"	2"	Very fine to fine grained, olive gray limestone with abundant calcite pathces. Sample L-27

Thickness Cum.	Interval	Description
26'7 1/2"	1"	Intraclasts and calcite patches in fine to very fine grained matrix. Sample L-27
26'8"	1/2"	Fine grained, light olive gray stringer.
27'	4"	Contains horizontal calcite patches lined up horizontally 1 to 2 mm across. Sample L-28
27'3/4"	3/4"	Light olive gray mudstone, few intraclasts of olive gray, very fine to fine grained limestone. Sample L-28
27'2 1/4"	1 1/2"	Olive gray, fine to very fine grained limestone which has calcite patches and rare light olive gray intraclasts. Sample L-28
27'3 1/4"	1"	Zone of fine grained, silty appearing stringer with some 2 inches long irregular lenses of olive gray limestone with clear calcite patches. No fossils observed. Sample L-28
27'5 1/4"	2"	Light olive gray to olive gray limestone, fine to very fine grained with calcite patches, becomes more argillaceous towards the top. Intraclasts of broken beds and laminae. Sample L-28
27'7 1/4"	2"	Shale, light olive gray laminae about 1/16 inch thick, slightly silty laminae become thinner at top. About 2 mm thick olive gray, very fine grained limestone at the top. Sample L-29
27'8"	3/4"	Very fine grained, olive gray argillaceous limestone with desiccation cracks at top of interal.
27'9 1/2"	1 1/2"	Light olive gray mixed with olive gray, fine grained. Sample L-30
27'11 1/4"	1 3/4"	Olive gray, very fine grained limestone with clear and white sparry calcite patches, average about 1 mm, largest about 3 mm. Sample L-30

Thickness Cum.	Interval	Description
28'1/4"	1"	Same lithology with wavy calcite patches.
28'1"	3/4"	Fine to very fine grained olive gray limestone with a few very small calcite patches and medium bluish gray to yellowish gray intraclasts.
28'1 1/2"	1/2"	Fine grained light olive gray layer.
28'3"	1 1/2"	Coarse grained fossil fragments and what appear to be angular medium bluish gray intraclasts may be fossils filled with finer material. Also, white and clear calcite possibly filling or replacing fossils.
28'3 1/4"	1/4"	Layer of light olive gray, fine grained argillaceous limestone or dolomitic limestone.
28'5"	1 3/4:	Very fine grained limestone with fossil fragments, calcite birdseyes interlamina. Cross laminations present also ripple marks at top, mudcracks on bottom of Sample 31 of above interval.
28'5 1/4"	1/4"	Fine grained, light olive gray to yellowish gray, mud cracked. Calcite patches. Sample L-31
28'6 1/2"	1 1/4"	Fine grained with interlamina birdseyes, about 5 mm across. Cross laminations. Fossils and fossil fragments filled or replaced with calcite. Intraclasts of underlying lithology. Top of bed highly weathered with what appears to be a good deal of desiccation. Sample L-31
28' 11 3/4"	5/4"	Light olive gray, very fine grained mudstone, may be some fine grained. Weathers yellowish gray with some grayish black. Mud cracks. Sample L-32 and L-33
29' 1 3/4",	2"	Olive gray, fine to very fine grained limestone with birdseyes of calcite toward the top 1 1/2 inches. Very fine grained, light olive gray intraclasts. Sample L-34
29'3 1/4"	1 1/2"	Shaly limestone.
29'7 1/4:	4"	Light olive gray, fine grained mudstone with a few calcite patches possibly fossil fragments. A few patches of very fine grained fossil fragments.

Cum.	Thickness Interval	Description
29'9 3/4"	2 1/2:	Coarse grained intraclasts and fossils and fossil fragments. Some fossil filled and replaced with calcite, others filled with fine grained matrix. Large brachiopods. Intraclasts of lighter color than the matrix. Sample L-35
29'10 1/4"	1/2"	Fine grained, light olive gray with possible limestone intraclasts.
29'11 3/4"	1 1/2"	Coarse grained as in Sample L-35 and also laminations and some stringers of fine grained to mostly very fine grained matrix. Pelecypods, ostracods (?), brachiopods on weathered surface. Dark laminae on surface. Sample L-36
30'1/2"	3/4"	Fine grained, yellowish gray stringer.
30'4"	3 1/2"	Olive gray, very fine grained (90 percent) with light olive gray, fine grained stringers (10 percent). Stringers are laminated, maybe cross laminated, with alterations of thin very fine grained laminae and fine grained. Some interlamina birdseyes of calcite. Some suggestion of mudcracks that have been filled with fine grained material. Sample L-37
31'4"	12"	Alternation between fine grained and very fine grained, the very fine grained being in lenses and pods. The very fine grained matrix is olive gray with some birdseyes near the bottom of the lenses. Desiccation cracks across the fine grained portion filled with coarse material and very fine grained matrix. Yellowish gray, possibly burrows. Vertical cracks not continuous across beds. Polygons about 1 inch across on bedding planes. Some intraclasts apparently due to desiccation breakup. Sample L-38: Lower 6".
31'8 1/2"	4 1/2"	Very fine grained with birdseyes along laminae. Vertical fine grained filled mudcracks. Also lenses of fine grained 1/2 inch thick by 2 1/2 inches wide. Top 1 inch layer very fine grained with horizontal dark colored wavy laminae. Sample L-38 typical of whole interval of mixture of fine grained yellowish gray and very fine grained olive gray. Mud crack polygons average about 1 1/2 inch across.

Cum.	Thickness Interval	Description
32'10 1/2"	14"	Much the same lithology as below. High percentage of olive gray, very fine grained limestone with coarse patches in large lenses. Laminae that are in this interval average about 1/8 inch thickness. Mudcracking prominant top 3 inches. Some of the olive gray laminae are quite thin, about 1 mm. Sample L-39
33'1/4"	1 3/4"	Coarse grained angular intraclasts 1/8 inch to 1/2 inch, elongate and equidimensional. Jumbled. Interspersed with birdseyes and has very fine grained and sparry calcite matrix. Sample L-40
33'2 1/4"	2"	Fine grained yellowish gray with lenses of coarse grained material with very fine grained matrix. Sample L-41
33'4 1/4:	2"	Very fine grained with birdseyes.
33'6 1/4"	2"	Fine grained, yellowish gray laminated with darker lamina of very fine grained material.
33'7 3/4"	1 1/2"	Very fine grained with birdseyes. Looks like laminae through interval. Top of interval has some depressions, about 1/2 inch in some places.
33'9 1/2"	1 3/4"	Fine grained, yellowish gray with lenses or lamina about 1/4 inch thickness.
33'10 1/4"	3/4"	Olive gray, very fine grained with coarse grained patches making up about 40 percent of interval. Alternation of limestone and siltstone laminae.
34'3 1/4"	5"	Yellowish gray to light olive gray mudstone (dolomitic?) with laminae of olive gray limestone. The limestone has small (less than 1 mm) birdseyes of calcite which appear equidimensional. (Can not tell if fossils are present.) Middle 2 inches mostly olive gray with light olive gray cross laminations mud cracks or burrows beneath this 2 inch interval. Sample L-43
34'7 1/4"	4"	Alternating laminae of fine grained, yellowish gray silstone (dolomite?) and very fine grained, olive gray limestone. The laminae are bout 1/8 inch thick in the lower 3 inches and get smaller near the top with the fine grained, yellowish gray portion being dominant. Sample L-43

Thickness Cum.	Interval	Description
34'8 3/4"	1 1/2"	Primarily limestone, very fine grained and olive gray with thin laminae of yellowish gray, fine grained dolomitic siltstone. Olive gray, very fine grained laminae have calcite patches reaching 20 percent of the laminae.
34'9 1/2"	3/4"	Alternation of thin laminae of limestone and siltstone or dolomitic siltstone. Sample L-43
35'9 1/2"	12"	Similar lithology to L-43 approximately 60 percent limestone, 40 percent siltstone, except the olive gray, very fine grained limestone has lenses of coarse grained material either birdseyes or fossil fragments. The coarse limestones are convex upward into bell-shaped curves. Some of the very fine grained limestones have thin laminae.
36'3 1/2"	6"	Alternating laminae of fine grained, yellowish gray siltstone or dolomite and very fine grained, olive gray limestone with pods of coarse grains in the limestone and also coarse grained laminae. Toward the top the fine grained becomes dominant to about 80 percent of the constituents. Sample L-45
37'3"	11 1/2"	Similar to L-45 except the laminae are not as continuous as below. They seem to pinch and swell. The limestone becomes lenses with calcite patches. Not as much fine grained, yellowish gray maybe about 10 to 15 percent.
37'9"	6"	Dominated by birdseyes. Intraclasts also observed. Olive gray, very fine grained, with light olive gray irregular layers or stringers. Laminations with abundant birdseyes along them and some in vertical burrows or desiccation cracks. Abundant coarse intraclasts in lower 1 1/2 inches. Sample L-46A
39'4 1/4"	19 1/4"	More light olive gray than olive gray fine grained with clear calcite patches or birdseyes, some 1/8 inch to 3/16 inch across but mostly elongate. They are wavy, curl around seem to follow horizontal pattern. Mud cracking prominant on weathered surface. No fossils observed. Sample L-47
40'10 1/4"	18"	Light olive gray with clear patches of calcite or birdseyes widely disseminated but concentrated into zones about 2 to 3 inches and 8 1/2 inches to 10 inches from the base. Broken up

Thickness		Description
Cum.	Interval	

desiccation features or intraclasts. Top 2 inches the texture seems to be very fine grained with the clear and white calcite birdseyes, iron stains brownish red.
Sample L-48: About 10 inches from base.
Sample L-49: Top 2 inches.

40'11 1/2" 1 1/4" Light olive gray, very fine grained with large birdseyes, dark stains observed.
Sample L-50

41'9 1/2" 10" Very fine grained, light olive gray to olive gray and dark greenish gray takes on overall coarse look because of many intraclasts and fossils some being filled and/or replaced by clear calcite. Brachiopod valves, gastropods, crinoid columnals, ostracods (?), pelecypods. This interval rather dense. Intraclasts abundant.
Sample L-50A
Sample L-51

41'10 1/4" 3/4" Light olive gray, very fine grained mudstone weathers shaley. Laminae not apparent in the fresh rock. Fairly well mud cracked.

41'11 1/4" 1" Light olive gray and olive gray (lenses laminated and cross laminated) both colors very fine grained. Desiccation features filled with calcite. Small mud crack polygons on weathered surface.

42'1/4" 1" Light olive gray mudstone very large mud crack polygons also very fine grained, olive gray.

42'3 1/4" 3" Very fine grained, olive gray and light olive gray mudstone, large orthocone cephalopod, birdseyes in olive gray probably interlamina. Some coarse concentrations of what seem to be fossil fragments.
Sample L-52

43'3 1/4" 12" Similar to lithology below. Bed 2 inches thick fine grained to very fine grained with stringers of fine grained. Light olive gray, nodular looking (interlamina birdseyes in fine to very fine grained, olive gray).
Sample L-53: 3" thick typical.

44'3 1/4" 12" About same as below. One inch to three inch beds of mudstone, some calcite stringers mostly horizontal.

Cum.	Thickness Interval	Description
44'6 1/4"	3"	Similar lithology, light olive gray with olive gray mottling or stringers. One perpendicular to bedding possibly filling desiccation crack.
45'2 3/4"	8 1/2"	Very fine grained, light olive gray, olive gray mottling, nodular appearing patches of coarse grained stringers or lenses do not persist. Gastropods, not much evidence of desiccation.
45'10 3/4"	6-8"	Mostly olive black to olive gray, fine to very fine grained with what appear to be ostracods. Fine grained matrix with patches, coarse sparry calcite and calcite patches.
46'3/4"	1 1/2-2"	Coarse grained, fossil fragments, abundant sparry calcite. Sample L-55
46'3 1/4"	2 1/2"	Fine grained to very fine grained, olive gray, may be thin shale parting. Sample L-55A
46'5 1/4"	2"	Brachiopod fragments, alternation of patches of coarse grained material and very fine grained matrix with calcite patches.
46'7"	1 3/4"	About olive gray, fine to very fine grained 10 percent consists of coarse fraction, white calcite filling fossils or voids. Fossil hash appearance on surface. High spired gastropods, pelecypods, or brachiopod fragments. Quite fossiliferous.
46'10"	2-3"	Wavy algal mat looking texture, tetradium fragments. Sample L-56
46'11 1/2"	1 1/2"	Similar to algal mat appearing lithology and coarse grained with calcite patches.
48'2 1/2"	6-12"	Covered
48'8 1/2"	6"	Comparable to lithology below.
48'10"	1 1/2"	Olive gray, whole brachiopod, other fossil fragments in very fine grained matrix. Small amount of greenish mottling. Sample L-57
48'11 1/4"	1 1/4"	Similar lithology to sample L-57. Wavy algal laminations going through beds.

Cum.	Thickness Interval	Description
49'2 1/4"	3"	Olive gray, fine grained to very fine grained occasional dark patches, look like iron stains.
49'4 1/4"	2"	Light olive gray with calcite patches possibly filling fossils.
50'1 1/4"	9"	Similar lithology with coarse patches, nodular appearing. Pinching and swelling of beds. Light olive gray to olive gray interval 4 inches from top has coarse grained area. Brachiopod fragments. Sample L-58 Sample L-58A: 4" from top.
51'1 1/4"	6-12"	Covered.
51'2 3/4"	1 1/2"	Light olive gray - olive gray similar to lithology below.
51'6 1/4"	3 1/2"	Coarse grained, primarily fossil fragments, patches of white calcite, tetradium fragments, coral brachiopod fragments, etc. Also fine grained, olive gray. Some white calcite. Sample L-59 Sample L-59A
52'1/4"	6"	Chert, 1 inch on top, silicified down into rock. Coarse grained abundant coral probably tetradium in (?) life position with very fine grained matrix. Gastropods large patches of sparry (white) calcite. Chert olive black to grayish black. Bryozoans on weathered surface coarse grained. Sample L-60A Sample L-61
55'1 1/4"	37"	Covered, probably including a bentonite as indicated by clayey soil mostly pale greenish yellow and weathers dark yellowish orange. Appears to be drag folded. Unable to tell where the top of the bentonite is located.
55'2 1/4"	1"	Seems to be a chert or silicified brachiopod and crinoid columnals. Energy in the environment must have been relatively high, fossils standing on edge, overturned, etc. Sample L-62
55'9 3/4"	7 1/2"	Limestone olive gray to medium dark gray faint greenish orange streaks in lower portion. Bryozoans weather out on surface. Irregular partings on surface. Coarse grained layer about 1/2 inch thick. A few calcite patches probably filling bryozoans. Sample L-63: Bottom 2".

Cum.	Thickness Interval	Description
55'10 1/4"	1/2"	Shale (?) highly weathered light olive gray with yellowish brown stains.
55'11 3/4"	1 1/2"	Laminated shale fine grained to very fine grained, light olive gray. Sample L-64 Sample L-64A
56'3/4"	1"	Covered, possibly weathered shale above.
56'5"	2 1/4"	Limestone - olive gray with yellowish brown streaks mostly very fine grained with coarse grains probably fossils, some sparry calcite filling brachiopod fragments. Some fine grained mottles horizontal and vertical. Sample L-65
56'8 1/4"	3 1/4"	Limestone about same lithology as L-65 except top 3/4" becomes somewhat coarse grained in fine to very fine grained matrix due to bryozoans. Some fine grained burrow mottling. Sample L-66
57'3 1/4"	6 1/2-7"	About the same lithology exhibited by Samples L-65, L-66, but with lenses, patches, and stringers of coarse grains possibly fossil fragments (hash). Brachiopods scattered through very fine grained portion also bryozoans, crinoid (?) columnals, and pelecypods. Top 1 1/4 inches fine to coarse grained with very fine grained filling fossils (?) large (probably Rafinesquina sp.) brachiopods. Also, orthocones filled with sparry calcite. Irregualar surface at bottom of top 1 1/4 inches probably cross sections of ripple marks. Sample L-67 Sample L-68: Top 2 1/2".
57'5 3/4"	2 1/2"	Olive gray with light brown, very fine grained. Occasional fossil fragment probably bryozoans and brachiopods.
57'8 3/4"	3"	Very fine grained, olive gray limestone with bryozoans. Irregular thin light olive gray partings, possible algal mats. Sample L-69
57'11 1/4"	2 1/2"	Limestone very fine grained, olive gray (about same as L-69) some coarse grained patches. Mottling may be burrows, some vertical. Sample L-70

Cum.	Thickness Interval	Description
58'4 1/4"	4-5"	Olive gray limestone, very fine grained with coarse grains in the form of fossils including brachiopods, coiled gastropods. Calcite 2-3 mm possibly filling voids or fossils or replacing fossils.

TOP OF CARTERS LIMESTONE, UPPER MEMBER

SUBSEQUENT UNITS LOWER PART OF HERMITAGE FORMATION

Cum.	Thickness Interval	Description
58'8 1/4"	2-4"	Olive gray to olive black to black mixed coarse to very fine grained limestone, mostly coarse. Some very fine grained rounded intraclasts. Abundant brachiopods, bryozoans, and other fossil fragments some with sparry calcite.
59'10 1/4"	14"	Dusky yellowish brown coarse grained limestone which becomes moderate yellowish brown near the surface possibly due to solution. Grains in lower part, about 1 mm across fossil fragments of brachiopods. A few voids near the top unfilled fossils. Sample L-73: Typical top 7-8".
60'1 1/4"	3"	Coarse grained fossils orthocone cephalopods, brachiopod some filled with pink calcite. Many voids. Also what appear to be intraclasts of fine or very fine grained limestone. Some places where fossils dissolved. Sample L-74
61'6 1/4"	17"	Limestone, fetid, mostly coarse grained fossil fragments. Some bands of fine grained limestone with fossils and fragments abundant. Olive black or maybe between olive gray and olive black color. Large brachiopods concentrated in 1 1/2 inches at bottom, and about 2 inches of the middle. Then abundant fossils in a fine grained matrix. Top 6 inches coarse grained large fossil fragments with much white to pink calcite filling cavities and fossils. Separation between fine grained and coarse grained irregular probably due to current. Sample L-75: Top 5".
61'7"	3/4"	Fetid limestone, mostly brownish black, fine to coarse grained fossil fragments brachiopods, crinoid columnals, possibly some bryozoans.

Cum.	Thickness Interval	Description
61'8 1/2"	1 1/2"	Coarse grained limestone with patches of very fine grained matrix (30 percent) olive gray to olive black. Solitary rugose corals. Brachiopod, crinoid columnals. Sample L-76
61'10"	1 1/2"	About the same lithology as Sample L-76. Contact between beds irregular (? Ripples or algal mats.)
62'2 1/2"	4 1/2"	Olive gray to olive black mostly coarse grained limestone. Abundant brachiopod fragments. Very fine grained matrix in spots about 25 percent of total unit. Coral, bryozoans, brachiopods, gastropods, crinoid columnals. Two prominant wavy stringers. Sample L-77 Sample L-77A
62'6"	3-3 1/2"	Coarse grained limestone. Most grains about 2 mm. Large white patches of sparry calcite filling brachiopods. Olive black to olive gray color. Sample L-78
62'7 3/4"	1 3/4"	Mostly very fine to fine grained, olive black to brownish black. Top of interval very irregular. Fossils include brachiopods and gastropods.
62'10 3/4"	3"	Coarse grained. Large brachiopod fragments and disarticulated valves, jumbled. Some bryozoans calcite replaces. Some fine grained to very fine grained matrix.
63'2 3/4"	4"	Fine grained to coarse grained fragments of brachiopods, bryozoans and coral. 70 to 80 percent of interval made up of fragments of about 1 mm range.
63'5 1/4"	2 1/2"	Coarse grained limestone brownish black some olive gray patches.
64'8 1/4"	15"	Coarse grained limestone with very fine grained matrix. Brachiopod fragments some large, about 3/4", voids filled with calcite. Sample L-79

BURKE SECTION

Vandever quadrangle, Tennessee, 7.5 minute series Topographic 109-SE (1956). See Figure 1, page 4, for location. The base of the section to the T-3 bentonite is located in the field north of the road 1,000 feet southeast of Burke (BM18DY997) (Tennessee Coordinates 504, 400N., 2,292,500E. to 504,500N., 2,292, 650E.) The upper part of the section is located about 700 feet southeast of Burke (BM18DY997) in ditch along the north side of the road (Tennessee Cooordinates 504,360N., 2,292,200E., to 504,400N., 2,292,350E.)

UPPER PORTION OF CARTERS LIMESTONE, LOWER MEMBER

Thickness		
Cum.	Interval	Description
3"	3"	Very fine grained, dark yellowish brown limestone with slightly lighter colored fine grained burrow filling. Small, about 1 to 2 mm, calcite patches with horizontal olive gray fine grained area near top.
6"	3"	Alternating very fine grained and fine grained limestone. Fine grained material probably represents burrow filling. Calcite patches, some as large as 1/2 inch diameter, may be associated with crinoid and brachiopod fragments (?). Sample B-1
1'3"	8"-9"	Very fine grained, dark yellowish brown with slightly lighter fine grained horizontal burrows with brownish black partings. Bryozoans on weathered surface. Sample B-2
1'4 1/2"	1"-1 1/2"	Chert nodules brownish gray to brownish black, some about 6 inches long. Undulating smooth surface. Fine grained appearance.
1'6 1/2"	1"-2"	Same as B-2

Cum.	Thickness Interval	Description
1'10 1/2"	3"-4"	Coarse grained, approximately unidimensional, about 1 mm average, some larger patches of calcite. Sample B-3
2'4 1/2"	6"	Very fine grained with fine grained burrows about the same as B-2. Chert in a few irregular nodules. Fine grain due to crystallization or fine grains in chert (looks unusual). Sample B-3A
2'9"	4 1/2"	Mostly very fine grained, dark yellowish brown with horizontal fine grained burrows. Some vertical connections. Sample B-4
3' 1/2"	3 1/2"	Very fine grained, dark yellowish brown limestone with fine grained horizontal burrows (?) weathered surface suggests laminations. Appears graded. Sample B-5
3' 2 1/2"	2"	Zone of fine grained with very fine grained material filling burrow (??). Sample B-6
3' 5 1/2"	3"	Very fine grained with horizontal fine grained stringers. Large, 1/2 inch to 1/4 inch, calcite patches, probably brachiopods or orthocones, crinoid columnals, cupcoral. Sample B-7 Sample B-7A: Fossil (coral?)
4' 1 1/2"	8"	Yellowish brown, very fine to fine grained with definite fine grained burrows that have spots that are both darker and lighter. (Fine grained burrow's weathering characterize the surface which is light gray with yellowish gray stringers.) Sample B-8
4' 8 1/2"	7"	Very fine grained, dark yellowish brown with fine grained burrows which are mostly horizontal, but others are oblique to bedding and vertical. Brachiopods, very sparse, some coarse material, fragments of fossils. Sample B-9
4' 9 1/4"	3/4"	Fine to very fine grained matrix with fossils, brachiopods, filled with calcite and mud. Solitary coral, crinoid columnals. Sample B-10

Thickness Cum.	Interval	Description
5' 5 1/4"	8"	Very fine to fine grained matrix with fine grained burrows. Some coarse patches, crinoid columnals, etc. calcite. Sample B-11
6' 1 3/4"	8 1/2"	Very fine grained to fine grained with fine grained burrows, mostly horizontal. Sample B-12: Lower 2"
7' 1/4"	10 1/2"	Mostly fine grained, between dark and dusky yellowish brown, some calcite patches. Fractures filled with calcite. Sample B-14: Top 2 1/2 inches
7' 9 3/4"	9 1/2"	Chert, 1 1/4 inch to 2 inches thick almost continuous layer, just varies in thickness. Brownish black, highly fractured, holes on weathered surface. Fine grained texture on weathered surface. Followed by 4 1/2 inches of mostly fine grained, between dark and dusky yellowish brown. Some calcite patches. Sample B-14: Bottom 2"
8' 1/4"	2 1/2"	Coarse grained, brachiopod, crinoid, etc., fossils. Sample B-15: All
8'2 1/4"	2"	Very fine to fine grained with some coarse grained, dark yellowish brown, some of coarse fossils filled with calcite. Brachiopods. Sample B-15: All
8'5 1/4"	3"	Very fine grained to fine grained, dark yellowish brown limestone with fine grained filled burrows. Many coarse fossils and fragments. Bryozoans and silicified area. Sample B-16
8'6 1/2"	1 1/4"	Coarse grained, almost unidimensional fossil fragments, may be a lens. Sample B-17
9'4 1/2"	10"	Very fine grained with fine grained stringers (burrows?). Large colony of tabulate coral (probably in life position) 14 inches across, also 6-8 inches tabulate coral. Coral filled with calcite. Some brachiopods, crinoid columnals, byrozoans observed. Sample B-18 Sample B-18A
9'10 1/2"	6"	Very fine grained, dark yellowish brown limestone with fine grained burrows.

Cum.	Thickness Interval	Description
10'1 1/2"	3"	Coarse grained limestone of fossils including solitary coral, bryozoans and crinoid columnals. Sample B-19
10'5 1/2"	4"	Very fine grained with fine grained, irregular horizontal partings, weathers nodular. Sample B-20
10'7"	1 1/2"	Very fine to fine grained limestone with coarse grains abundant, dark yellowish brown; fossils and fragments make up coarse fraction. Top of interval, coarse grained. Brachiopods, crinoids, and bryozoans weathering out on surface. Sample B-21
10'11"	4"	Very fine to fine grained, dark to dusky yellowish brown limestone with coarse grained layers of fossils and fossil fragments. Brownish black chert nodules 1/2 to 1 inch thick. Dark olive black irregular fine grained partings. Sample B-22
11' 1/2"	2 1/2"	Very fine grained with mostly horizontal fossils, bryozoans, brachiopods, crinoid columnals, and brownish black chert in nodules approximately 1/2 inch x 2 inches with the long axis horizontal. Sample B-23
11'4"	2 1/2"	Chert. Limestone replaced by chert, many silicified brachiopods, bryozoans, ostracods, etc. Sample B-24

TOP OF CARTERS LIMESTONE, LOWER MEMBER

SUBSEQUENT UNITS ARE CARTERS LIMESTONE, UPPER MEMBER

Cum.	Thickness Interval	Description
14'8"	40"	Covered. T-3 Bentonite (?)
15'8"	12"	Olive gray, very fine grained, laminated limestone with calcite patches. Birdseyes along lamina and possible mud cracks. Sample B-25: Top 2 inches.

Thickness Cum.	Interval	Description
16'3"	7"	Fine to coarse grained (intraclasts), light olive gray to olive gray with yellowish gray to light olive gray streak approximately horizontal. Many birdseyes about 1 mm in size. Some large birdseyes (?). Sample B-26
16'6"	3"	Olive gray mostly very fine grained argillaceous limestone or dolomite seems to be weathered into mud crack polygons. Also patches of calcite in lenses. Sample B-27
19'4"	34"	Covered.
20'	5"-8"	Light olive gray, silty appearing laminations alternating with very fine grained limestone. Indications of mud cracks and birdseyes in the very fine grained, olive gray to light olive gray. On weathered surface of the outcrop is yellowish gray color with what appears to be silty mud filling around weathered polygons of very fine grained limestone. Sample B-28
21'8"	20"	Covered
21'11"	2"-3"	Olive gray, laminated siltstone or dolomitic limestone (?) with layers of 1/4 inch darker, very fine grained with birdseyes. Sample B-29A
22'2"	3"	Very fine grained with birdseyes or calcite alternating with 1/4 to 1/2 inch layer of light olive gray (siltstone, dolomite, etc.?); mud cracks on bottom. Sample B-29
22'6 1/2"	4 1/2"	Very fine grained, olive gray with birdseyes alternating with bands of fine grained, light olive gray; mud cracked. Sample B-30
23'6 1/2"	12"	Same lithology as B-30 below. Sample B-31: Bottom 3 inches.
24'6 1/2"	12"	Bedding not as even as units below (B-30, B-31). Same general lithology except more birdseyes and more fine grained than very fine grained. Sample B-32: Top 5 inches.

Cum.	Thickness Interval	Description
25'5 1/2"	11"	Alternating bands of very fine grained, light olive gray dolomite or argillaceous limestone with small birdseyes. Sample B-33: 3 inches center of unit.
26'5 1/2"	12"	Covered
27'7 1/2"	14"	Light olive gray alternating with light olive brown, mostly very fine grained. The light olive gray areas have some birdseyes. Some dark dendrites associated with light olive brown areas. Thinly laminated overall. Sample B-34
28' 1/2"	5"	Light olive gray (5Y5/2) to olive gray (5Y3/2) with thin laminations, some are close to light olive brown to dusky yellow. Some 1/2 inch beds have birdseyes. Grayish brown, 1 inch or so dendrites. Sample B-35
28'4 1/2"	4"	More light colored laminae, some grayish brown dendrites associated with mostly vertical and some diagonal fractures or mud cracks. Sample B-35: Top 1 inch.
29'4 1/2"	12"	Lithology, color, and primary freatures very similar to lithology in sample B-35 with alternation of dark and light color, of different thicknesses in the interval, color more light in center, darker on top and bottom. Some indication of mud cracks on weathered surface.
30'7 1/2"	15"	Between light olive gray (5Y5/2) and yellowish gray (5Y7/2) laminated argillaceous limestone or dolomite very fine grained with interlamina calcite patches (birdseyes) abundant. Sample B-36
32'5 1/2"	22"	Alternation between light olive gray with and without interlamina birdseyes. Large 2-3 inch mud crack polygons, cracks 1/4 inch wide in places. Orthocone cephalopod. Sample B-37: Top 8 inches.
34'6"	24 1/2"	Still light olive gray (5Y5/2), laminated. 3/4 inch stringer with abundant fossil fragments. Jumbled; and wavy top surface may be ripple marks. Mud cracks with polygons that average about 1 inch across, cracks about 1/8 inch wide. Mud cracks filled with birdseyes, also interlamina birdseyes. Sample B-38: 6 1/2" above base Sample B-39: Top 2 inches.

Cum.	Thickness Interval	Description
35'	6"	Argillaceous to silty light olive gray limestone with birdseyes.
36"	6-12"	Covered
36'4"	4"	Olive gray limestone with large calcite patches (1/4 to 1/2 inch) may be filling fossils. Very fine to fine grained matrix. Few small calcite patches. Tetradium fragments, braciopods. Sample B-40
37'1/2"	8 1/2"	Olive gray, very fine grained, with calcite birdseyes or fossil, Tetradium fragments, gastropods, brachiopods, more abundant in a fine to very fine grained matrix in top one inch. Sample B-41: Top 5"
37'3"	2 1/2"	Olive gray to light olive gray very fine grained matrix with 30 percent large white calcite, possibly filling voids between fossils. Tetradium fragments abundant. Sample B-42
37'4 1/2"	1 1/2"	Olive gray to light olive gray, very fine grained limestone with sparry calcite-filled fossils, brachiopods, etc., making up 30 percent to 40 percent of unit. Tetradium filled with very fine grained limestone. Sample B-43
37'6 1/2"	2"	Covered.
38'2 1/2"	8"	Olive gray very fine grained with fine grained greenish gray burrows and olive black organic-appearing material. Sample B-44
38'3 1/2"	1"	Olive gray to light olive gray, many birdseyes and fossils filled with calcite throughout. Top 1/2 inch coarse grained fossil hash. Tetradium fragments, mud-filled brachiopods, trilobite. Burrows mostly vertical.
38'4 1/2"	1"	Shale with nodular limestone. Bryozoans or possibly burrows filled with limestone mud. Zygospira sp. observed. Sample B-45
38'5 1/2"	1"	Mostly fine grained, mostly laminations. Fine grained, grayish orange mottling. Sample B-46
38'6 1/4"	3/4"	Shaly limestone with abundant fossils. Sample B-47

Thickness Cum.	Interval	Description
38'7"	3/4:	Coarse grained fossil hash, in very fine grained matrix. Sample B-48
38'8"	1"	Olive gray, fine grained to very fine grained, with abundant fossils, brachiopods (Zygospira sp.), trilobite fragments, bryozoans, ostracods, pelecypods, crinoid columnals. Sample B-49
38'11"	3"	Olive gray very fine to fine grained limestone. Cross-bedded with calcite patches, possibility of burrows. Sample B-50
39' 3/4"	1 3/4:	Olive gray with dark brown dendrites, very fine grained with light olive grayish orange horizontal burrows, some vertical. Fine grained material filling burrows or mud cracks. Sample B-51
41'6 3/4"	24"-30"	Covered.
42'1 3/4"	7"	Olive gray (5Y5/2) to light olive gray and medium light gray, very fine grained to fine grained limestone with abundant sparry calcite, coarse fossils and fragments. About 2 inches in the middle of interval shaly appearing with irregular laminations. Tetradium (?) near top of interval appears to be broken into fragments. Sample B-52 Sample B-52A
42'8 3/4"	7"	Olive gray to light olive gray and medium light gray, very fine to coarse, mostly very fine to fine grained matrix. Patches and layers of calcite filling fossils. Gastropods, brachiopods, abundant Tetradium in life position (?) and concentrations of fragments. Sample B-53
42'11 3/4"	3"	Very fine to fine grained with brownish black chert.
43'3/4"	1"	Weathered brownish black to olive black chert. Fossil, brachiopod, observed. Sample B-54
46'3/4"	36"	Covered (possibly contains bentonite).
46'10 3/4"	10"	Fine to very fine grained, medium light gray (N6) to medium gray (N5). Weathers shaly. Sample B-55

Thickness Cum.	Interval	Description
47'3 3/4"	4 1/2-5"	Covered.
47'6 3/4"	3"	Fine to very fine grained, medium light gray to olive gray with white and clear calcite filling mostly vertical fractures or mud cracks. Irregular contact with coarse grained, dark colored overlying lithology. "Dikes" of overlying lithology reaching down into this interval. Sample B-56 Sample B-56A

TOP OF CARTERS LIMESTONE, UPPER MEMBER

SUBSEQUENT UNITS LOWER PART OF HERMITAGE FORMATION

Thickness Cum.	Interval	Description
47'10 3/4"	4"	Coarse grained brownish gray to brownish black, abundant fossils and fossil fragments.
48'11 3/4"	13"	Fine grained (mostly) to coarse grained, brownish gray to brownish black, mostly lighter shades with at least one large brachiopod. Sample B-57
49'2 1/4"	2 1/2"	Fine to coarse grained brownish gray to brownish black below nodular limestone (parting irregular, cross cutting). Fossil fragments of brachiopods, bryozoans, and crinoid columnals. Sample B-58
49'11 1/4"	8-9"	Coarse grained with some patches of fine grained or finer coarse grained. Large brachiopods and bryozoans. Abundant white calcite filling fossils. Rafinesquina, crinoid columnals, cephalopod (orthocone), gastropods, etc., irregular partings at top of the interval. Sample B-59
50'4 1/4"	5"	Fine to coarse grained (carbonate sand and larger) composed of mostly fossil fragments. Some brachiopods and bryozoans not broken beyond recognition. Sample B-60

Cum.	Thickness Interval	Description
50'10 1/4"	6"	Large patches of white sparry calcite filling voids (??) fossils. Some filling large brachiopods. Bryozoans, crinoid fragments also observed. Sample B-61
50'11 3/4"	1 1/2"	Brownish black to brownish gray, very fine grained with coarse fossils. Mostly bryozoans and brachiopods. Sample B-62
51'2 3/4"	3"	Very fine grained to fine grained with some fossils and fragments as coarse fraction, brownish gray to brownish black. Weathers much smoother than enclosing rocks. Appears to have fossil fragments included in fine to very fine grained matrix. Sample B-63
51'4"	1 1/4"	Coarse grained with some very fine grained material consisting mostly of brachiopods and fragments of brachiopods. Also bryozoans. Sample B-64
51'6 3/4"	2 3/4"	Fine to very fine grained matrix with abundant fossils and fragments (note peculiar structure on sample B-65). Mud-filled and calcite-filled gastropods and brachiopods. Bryozoans abundant. Sample B-65
51'11 1/2"	4 3/4"	Coarse grained fossil fragments in very fine to fine grained matrix. Abundant fossils and fragments. Jumbled irregular top surface. Fine to coarse grained, brownish black mostly with some brownish gray in top three inches and finer grained. Sample B-66
52'3 1/2"	4"	About the same lithology as below except gets coarser near the top.
52'7"	3 1/2"	Fine grained to very fine grained matrix colored brownish gray with abundant coarse calcite and/or fossils and fossil fragments. Brachiopods and bryozoans observed. Sample B-67
52'9 1/4"	2 1/4"	Fine to coarse grained, small (less than 1 mm) ostracods, pelecypods, and crinoid columnals. Sample B-68
53'1 1/4"	4"	Fine to coarse grained brownish black brachiopod fragments. Some very fine grained matrix.

Cum.	Thickness Interval	Description
53'6 1/4"	5"	Very fine grained matrix with coarse fossils and fragments. Some fine grained wavy about 1/4 inch partings. May be solution or burrows. Sample B-69
54'8 1/4"	14"	Covered.
55'11 1/4"	15"	Two to three inch beds. Fine to coarse grained with some very fine grained matrix. Grains over 1/8 inch. Some 1/2 inch patches of sparry calcite. Bryozoans in some beds on weathered surface. Interval weathers smoother than those below. Seems to have darker color near brown black. Sample B-70

PEE DEE RIDGE SECTION

Vandever quadrangle, Tennessee, 7.5 minute series Topographic 109-SE (1956). See Figure 1, page 4, for location. The section is located in the stream bed where Pee Dee Ridge joins the Cumberland Escarpment. Its base is about 1,200 feet northwest of the southeast corner of the map and extends up the stream about 400 feet. (Tennessee Coordinates 497,000N., 2,296,350E. to 496,800N., 2,296,700E.)

UPPER PORTION OF CARTERS LIMESTONE, LOWER MEMBER

Cum.	Thickness Interval	Description
9"	9"	Limestone, very fine grained, brownish gray (5YR4/1) with fine grained, light olive gray mottling (? burrows). Coarse grained lenses mixed with very fine grained matrix. Grains consist of white calcite filling brachiopods. Weathers light gray. Horizontal ridges on outcrop at about one inch intervals. Calcite filled fractures. Sample P-1

Cum.	Thickness Interval	Description
1'	3"	Limestone, coarse grained, with patches of very fine grained brownish gray color, patches of white calcite and fine grained light olive gray burrow mottling. Crinoid columnals on weathered surface probably along with brachiopod fragments. Chert angular, 2 cm on side. Sample P-2
1'5"	4 1/2-5"	Limestone, argillaceous, olive gray (5Y4/1), with very fine grained, light olive gray mottling (5Y5/2), somewhat nodular. Fine grained, light olive gray burrow mottling weathers into angular fragments.
1'9"	4"	Limestone, very fine grained, brownish gray (5YR4/1) to olive gray (5Y4/1) with occasional brachiopod fragments. Fine grained, light olive gray mottling. Sample P-3
2'	3"	Very fine with more coarse material, crinoid columnals.
2'4"	4"	Very fine grained, brownish gray to olive gray with horizontal stringers of light colored fine grained material. Some burrows weathering out on the surface.
2'6"	2"	Very fine grained brownish gray to olive gray with olive black (5Y2/1) mottling. Weathers light gray. No fossils observed.
3'	6"	Very fine grained dusky yellowish brown (10YR2/2) with clear calcite patches about 2 to 4 mm, may be fossil fragments. Fine grained mottling pale yellowish brown (10YR6/2). Brownish black coal-like material. Sample P-4
3'2"	2"	Coarse grained limestone with white and clear calcite in very fine grained matrix that is dusky yellowish brown (10YR2/2). Also fine grained, pale yellowish brown (10YR6/2) burrows. Grades laterally into more very fine grained burrow mottled limestone.
4'7"	17"	Very fine grained, dusky yellowish brown (10YR2/2) with fine grained, pale yellowish (10YR6/2) burrows. Burrows vary in frequency from abundant to rare. Sample P-5: lower 3 inches.
4'8 1/4"	3/4-1 1/4"	Chert bed-fairly continuous, dusky yellowish brown - eliptical patches, olive black (5Y2/1) weathers angular.

Thickness Cum.	Interval	Description
4'10 1/2"	2 1/4"	One inch at bottom very fine grained, dusky yellowish brown (10YR2/2). irregular boundary looks like stylolite with fine grained limestone above, looks mottled. Color of fine grained varies from dark yellowish brown (10YR4/2) to pale yellowish brown (10YR6/2). Very fine grained patches in fine grained top of interval has very well exposed burrows weathered out. Some about 1/2 inch across, mostly horizontal. Sample P-6 Sample P-6A: Just above chert.
5'1"	2 1/2"	Very fine grained, dusky yellowish brown (10YR 2/2) with fine grained burrows weathered out on the bottom and top. Chert nodules in this interval, vary in thickness from 1/2 to 1 1/2 inches, are similar to chert below. Sample P-7A
5'2 1/2"	1 1/2"	Very fine grained over chert, possibly stylolite between the two lithologies. Sample P-7
5'4"	1 1/2"	Covered.
5'11"	7"	Similar lithology to that below. Very fine grained and fine grained burrow mottling (dusky yellowish brown) (10YR2/2). Fractures filled with white calcite, questionable trilobite fragments. Surface weathers smooth except for fine grained horizontal stringers.
6'5 3/4"	6 3/4"	Same as below, mostly very fine grained. Calcite filled fractures.
6'11 3/4"	6"	Very fine grained dusky yellowish brown (10YR2/2) burrows abundant in top 3 inches. Top 1 inch or so very fine grained with color between dusky yellowish brown (10YR4/2) and (10YR2/2). Sample P-8
7'2 1/4"	2 1/2"	Very fine grained, dusky yellowish brown between (10YR4/2) and (10YR2/2) with 3 inch x 3/4 inch lens of calcite mixed with burrows near top. Isolated small patches of clear calcite. Sample P-9
7'3 3/4"	1 1/2"	Very fine grained, same color (except maybe a little lighter) fine grained patches (burrows) isolated near bottom. Weathers grayish orange.

Thickness Cum.	Interval	Description
7'5 3/4"	2"	Very fine grained, dusky yellowish brown with fine grainedburrow mottling.
7'8 3/4"	3"	Very fine grained, dusky yellowish brown, some dark areas. Burrows filled with fine grained. No fossils observed. Burrows approximately 1/4 inch in diameter weathering on side of rock.
8' 3/4"	4"	Very fine grained, dusky yellowish brown (10YR2/2) some fine grained, pale yellowish brown (10YR6/2). Sample P-10
8'3 3/4"	3"	Coarse grained, large brachiopod fragments, cup coral and fossil fragments. Possible intraclasts in form of angular grains weathering out on the surface. The weathered surfaces of this interval have laminar appearance. Tabulate coral collected in fragments in horizontal position (long axis in horizontal position.) Sample P-10 Sample P-10A
8'8 1/4"	4 1/2"	Very fine grained, between dark yellowish brown (10YR4/2) and dusky yellowish brown (10YR2/2), some fine grained.
9'9'1/4"	13"	Very fine grained, close to dusky yellowish brown color. Brachiopod fragments rare. Fine grained, moderate yellowish brown burrow mottling. Burrows (?) intensify at about 7 to 9 inch interval.
9'11 1/2"	2 1/4"	Coarse grained crystalline calcite with some very fine grained, color between dark yellowish brown and dusky yellowish brown. Sample P-11
10'2"	2 1/2"	Very fine grained, same color as above.
10'4"	2'	Shaly limestone. Very fine to coarse grained. Coarse fragments possibly fossil debris.
10'7"	3"	Very fine grained with fossil fragments, irregular partings.
11'	5"	Coarse grained. Approximately equidimensional fossil fragments. Sample P-12

Thickness Cum.	Interval	Description
11'4 1/2"	4 1/2"	Mostly very fine grained with brachiopods (Zyospira sp.). Irregular nodules of chert. Irregular bedding surfaces possibly algal mats. Cup coral probably Zaphanthis sp. about 1 inch long. Secondary fractures filled with white calcite. Sample P-13
11'7 1/2"	3"	Very fine grained to fine grained limestone with shaly irregular bedding and olive black chert. Scattered fossil fragments possibly brachiopod, gastropods, also coral on weathered surface. Sample P-14
12'	4 1/2"	Alternating coarse and very fine grained brachiopod fragments, crinoid (?) columnals on bottom and probably contribute most to coarseness. Irregular bedded on weathered surface. Sample P-15
12'6"	6"	Very fine grained, dark yellowish brown to dusky yellowish brown, breaks angular. Irregular bedding with brownish black material coating.
12'7"	1"	Very fine grained with yellowish brown fine grained patches (burrows).
12'8 1/2"	1 1/2"	Coarse grained (mostly) with very fine grained matrix, one inch brachiopods weathering on bedding surface (unidentifiable).
13'8 1/2"	12"	Top 2 inches representative of interval. Mostly very fine grained with fine grained burrows. Irregular surfaces stand out with brownish black material.
13'11 1/2"	3"	Very fine grained with patches of coarse probably fragmented crinoid (?) columnals near dusky yellowish brown. Sample P-17
14'2"	2 1/2"	Dark yellowish brown, very fine grained to coarse. Graded laminations. Crinoid debris, brachiopods.
14'5 1/2"	3 1/2"	Coarse grained to very fine grained dark yellowish brown. The coarse material consists of fossils and fragments of crinoids, brachiopods, and/or ostracods. Irregular partings, graded thin beds. Sample P-18.

Cum.	Thickness Interval	Description
14'11"	5 1/2"	Very fine grained, dark yellowish brown with brownish black chert. Calcite in jointing (?). The chert is in nodules about 2 inches in diameter or less. Irregular partings prominant on weathered surface. Sample P-19
15'2"	3"	Covered.
15'4 1/2"	2 1/2"	Very fine grained, almost uniform texture. Dark yellowish brown. Sample P-20
15'5 1/2"	1"	Very fine grained with some coarse fossil fragments.
15'10 1/2"	5"	About the same as 1 inch below. Patches of chert and limestone replaced (?) by chert. Pyrite and calcite observed along with fragments of brachiopods and other fossil debris. Sample P-21A: 2" below chert.
15'11 1/2"	1"	Chert displaying current ripples with thin layer about 1/4 inch, smooth surface on bedding surface filling the ripples, axis of ripples strike N5°E. A suggestion of fossils on chert bedding surface. Sample P-21

TOP OF CARTERS LIMESTONE, LOWER MEMBER

SUBSEQUENT UNITS ARE CARTERS LIMESTONE, UPPER MEMBER

Cum.	Thickness Interval	Description
18'11 1/2"	36"	Covered including bentonite.
19'3 1/2"	4"	Brachiopod, pelecypod and/or ostracod fragments about 1/2 inch long, mostly horizontal convex upward. Clear calcite patches. Orthocone cephalopod transverse and longitudinal section. Some valves of brachiopods, etc., overturned. Sample P-22A
19'4 1/2"	1"	Becomes fine grained, moderate yellowish brown (10YR5/4).

Cum.	Thickness Interval	Description
19'6 1/2"	2"	Very fine grained matrix with coarse grains of brachiopod fragments. Sample P-22B
19'7"	1/2"	Fine grained, light olive gray (5Y5/2) with dark brown to black stains.
19'10"	3"	Laminated, shaly limestone or calcareous shale alters light olive brown (5Y5/6) and grayish olive (10Y4/2) Sample P-23
20'5"	7"	Very fine grained, light olive gray (5Y5/2) with streaks of moderate brown (5YR4/4). Also olive gray with patches of clear calcite filling fossil (probably). Dark patches probably trilobite fragments toward top of bed. Deep mud cracks present, large polygons, cracks filled with calcite. Cross bedding on weathered surface. Sample P-24A
20'10"	5"	Shaly limestone, olive gray, irregular partings with mud cracks. Sample P-25
21'2"	4"	Dark yellowish brown (10YR4/2), very fine grained. Patches and fracture fillings of white calcite. Fractures may be mud cracks. Traces of fossils, suggestion of mud cracks on bedding surface. Calcite observed along laminae. Sample P-26 Sample P-26A
21'8"	6"	Dark yellowish brown, very fine grained with coarse patches of calcite which become more prominent toward the top. Evidence of mud cracks on parting surfaces. This interval weathers very shaly and light gray at the top. Sample P-27 Sample P-27A
22'5 1/2"	9 1/2"	Fine to very fine grained, dark yellowish brown (10YR4/2). No visible fossils. Considerably mud cracked. Especially small mud cracks filled with white calcite, also clear calcite interlamina and in isolated patches. Sample P-28 Sample P-28A
22'11 3/4"	6 1/4"	Very fine grained, olive gray (5Y4/1) with patches of clear calcite. Sample P-29: Top 2".

Cum.	Thickness Interval	Description
23'5 3/4"	5-6:	Dark yellowish brown with light stringers, fine grained to very fine grained argillaceous limestone or dolomite with abundant calcite. Sample P-30
23'9 3/4"	3-4"	Fine grained to very fine grained, more laminated, no calcite observed. Sample P-30A: Top few inches.
24'7 1/4"	9 1/2"	Intraclastic limestone, intraclasts subangular to subrounded, some grayish blue green color but mostly light olive green to olive gray, very fine grained to fine grained. Abundant calcite patches. Possibly some brachiopod fragments. Sample P-31
24'9 3/4"	2 1/2"	Very fine grained, light olive gray or dusky yellow. Highly mud cracked on light brown weathered surface. Bird-seyes abundant. Sample P-32
25'2 1/4"	4 1/2"	Very fine grained, olive gray (5Y4/1) with calcite along laminations. Some fine grained stringers light tan color. Sample P-33: Bottom 1"
25'9 1/4"	7"	Fine grained, light olive gray argillaceous limestone alternating very fine to fine grained, olive gray with clear calcite patches and light olive gray rounded intraclasts. Sample P-34
26'3/4"	3 1/2"	Very fine grained, dark yellowish brown (10YR4/2) argillaceous limestone or dolomite with calcite patches in lower 3/4 inch. Vertical stylolite. Fine grained stringer near top. Sample P-35
26'2 1/4"	1 1/2"	Fine grained, light olive gray, argillaceous limestone bedded with darker, very fine grained. Surface possibly mud cracked or vertically burrowed. Sample P-36
26'4 1/4"	2"	Dark yellowish orange (10YR6/6), fine grained with very fine grained lenses of dark yellowish brown (10YR4/2), vertical joints or mud cracks. Sample P-37

Thickness Cum.	Interval	Description
26'6"	1 3/4"	Fine grained, as below, with scour filled with very fine grained. Mud cracks in the fine grained also filled with very fine grained material. Light olive gray. Sample P-38
26'7 3/4"	1 3/4"	Light olive gray, alternation of fine grained and very fine grained, some thin laminations and birdseyes. Lens shaped irregular beds not always pinching out.
26'10"	2 1/4"	Laminated, light olive gray, very fine to fine grained, looks much like shale alternating with very fine grained lenses of limestone with birdseyes which may be interlamina mud cracks. Sample P-39A
27'2 1/2"	4 1/2"	About the same as below only darker color. Birdseyes increase in size. Sample P-40
27'9 1/2"	7"	Alternating fine grained, light olive gray with uneven mud cracked surface followed by very fine grained, dark yellowish brown argillaceous limestone with interlamina birdseyes. Scour noted, also ripple marks. Sample P-41
28'1"	3 1/2"	Appears to have a little more argillaceous material. Still have layers of very fine grained birdseyed limestone with cross laminations. Some intraclasts. Sample P-42
28'11 1/2"	10 1/2"	Argillaceous limestone, very fine grained, light olive gray. Gets more argillaceous at top, also more laminated. Some coarse grained, irregular beds in very fine grained matrix. Abundant birdseyes. Mud cracks. Sample P-43
29'2 1/2"	3"	Fine grained, light olive gray, laminated, argillaceous limestone with a few birdseyes alternating with very fine grained, dark olive. Sample P-44
29'7"	4 1/2"	Very fine grained, olive gray to olive black with birdseyes filling cracks and along lamina. Sample P-45

Cum.	Thickness Interval	Description
30'2"	7"	Very fine grained, dark yellowish brown 910YR4/2) with birdseyes and laminations; alternating with light olive gray, large mud cracks, 3 to 4 inches across, mottling around birdseyes. Sample P-46
30'5"	3"	Dark yellowish brown (10YR4/2) somewhat typical of beds below. Laminae of fine grained, alternating with very fine grained material which has abundant birdseyes. Some birdseyes in vertical "zone" desiccation. Sample P-47
31'1"	8"	Olive gray (5Y4/1), very fine grained laminated with light brown streaks and interlamina birdseyes, also birdseyes in matrix. Birdseyes about 3 to 4 mm diameter. Sample P-48: Top 5" Sample P-48A: Bottom 3"
32'4 1/2"	15 1/2"	Fine grained to very fine grained, between olive gray (5Y4/2) and light olive gray (5Y5/2), may be dolomitic, evidence of mud cracks. Birdseyes average about 1 mm across. Sample P-49
33'5 1/2"	13"	Limestone becoming more argillaceous and/or dolomitic, color becoming lighter, very fine grained, has birdseye. Weathers yellowish gray (5Y8/1). Some suggestions of mud cracks on bedding surface. Sample P-50
33'8 1/2"	3"	Lithology changing, less argillaceous and fewer birdseyes, and not evenly distributed. Large areas of very fine grained, shaly fragments or intraclasts. Sample P-51
33'11"	2 1/2"	Very fine grained, light olive gray, somewhat laminated with birdseyes. Sample P-52
34'4"	5"	Very fine grained, light olive gray (5Y5/2) with abundant birdseyes along laminations. Large white calcite may be filling brachiopod. Sample P-53
35'8"	16"	Covered (8 ft. to 10 ft. bench in the stream).

Cum.	Thickness Interval	Description
36'2"	6"	Mostly very fine grained with zone of birdseyes along cross laminations and vertical cracks. Thin streaks of brownish orange followed by coarse grained fossil fragments possibly brachiopods, pelecypods, or ostracods. About 3/4 inch of very fine grained may be laminated with dark brown to brownish black stains along vertical planes due to mud cracks becoming iron stained. Sample P-54
36'3"	1"	Very fine grained, grayish olive (10YR4/2) limestone with narrow lens of fine grained with birdseyes or fossil fragments.
36'6"	3"	Very fine grained, grayish olive, laminated with dark brown stains and birdseyes. Ripple marks and mud cracks observed in this interval, possibly some chert. Sample P-55
37'4"	10"	Multicolored, very fine grained, laminated, mud cracked dolomite or argillaceous limestone, with iron stains along cracks, patches of birdseyes or fossil fragments. Wide mud cracks. Sample P-57
37'9 1/2"	5 1/2"	Very fine grained, olive gray with birdseyes along lamina, also white calcite filling fossils (brachiopods?), also brachiopod and ostracod shells on bottom. Possibly some intraclasts. Dark iron stains. Sample P-58
37'10 1/2"	1"	Very fine grained becoming coarse grained at top of bed, fossil fragments. Mud cracked. Sample P-59
38'2"	3 1/2"	Very fine grained, olive gray, mud cracks 1/8 inch wide. Sample P-60
38'3"	1"	Very fine to fine grained, matrix with birdseyes. Sample P-60
38'6 1/2"	3 1/2"	Very fine grained, olive gray mud cracks. Slightly laminated.

Cum.	Thickness Interval	Description
39'2 1/2"	8"	Shaly weathering, very fine grained with layers and lenses of coarse material, possibly fossil fragments or birdseyes. Small mud crack polygons. Weathers to yellowish gray (5Y8/1). Sample P-61: Bottom 1".
39'6"	3 1/2"	Limestone, very fine grained, brownish gray (5YR4/1) to olive gray with light olive gray. Some coarse grains abundant intraclasts, scattered fossil fragments filled with calcite. Sample P-62A
39' 9 1/4	3 1/4"	Olive gray to light olive gray, coarse grained limestone, much calcite filling fossils. Ostracods, brachiopods and Tetradium sp. debris in fine to very fine grained matrix. Sample P-64
40'4 1/4"	7"	1/2 to 1 inch irregular beds, very fine grained, olive gray (5Y4/1) with brownish black (5YR2/1) iron stains.
40'5 1/4"	1"	Very fine grained, olive gray with brachiopod fragments and white calcite. Sample P-65
40'7 1/4"	2"	Nodular limestone, very fine grained with calcite patches, dark brown material, light olive gray mottling. Sample P-66
40'10 1/4"	3"	Brownish gray (5YR4/1) to olive gray (5Y4/1) very fine grained matrix with lenses of coarse grained. Some brachiopod fragments, gastropods, sparry calcite, light olive gray mottling. Tetradium debris.
41'3 1/2"	5 1/4"	Vertical and horizontal greenish gray (5GY6/1) to grayish yellow green mottling associated with fine grained; to very fine grained, brownish gray (5YR4/1) to light olive gray (5Y6/1). Mottling mostly vertical, probably burrows partially filled with sparry calcite. Two inches coarse grained fossil fragments in very fine grained matrix above irregular parting. Trilobite debris, Tetradium fragments. Sample P-68
41'6"	2 1/2"	Very fine grained matrix with vertical mottling becomes fine grained to coarse grained near top. Probably vertical burrows, U-shaped burrow observed on polished surface. Burrows partly filled with calcite and fine grained material, cracks filled with calcite in matrix may be due to expansion, no evidence of mud cracks on bedding surface. Sample P-69 Sample P-69A

Cum.	Thickness Interval	Description
42'1 1/2"	7 1/2"	Fine to very fine grained, burrow mottled more horizontal than unit below, followed by fine to coarse grained, some fossil fragments (brachiopods or pelecypods) with burrows weathering out on top of interval. Possibly 1 inch shale bed or bentonite in this interval weathered to a high degree.. Sample P-70: Top 1"
42'10"	8 1/2"	Alternation of coarse grained fossil fragments in very fine to fine grained matrix. The very fine grained matrix has fine grained burrow mottling. Abundant Tetradium sp. fragments in the coarse fraction; fine grained filled gastropods, brachiopods. Possibly some mudstone or shale. Top 3/4", very fine grained to fine grained, olive gray. Sample P-71 Sample P-72 Sample P-73: Top 3/4"
43'7"	9"	Very fine grained limestone with irregular partings not continuous across outcrop. Top one inch, birdseyes observed. Sample P-74
43'9"	2"	Coarse grained, sparry calcite filling large brachiopods, etc., mostly crinoid columnals and bryozoans and possibly ostracods lensing in and out.
44'	3"	Very fine grained, olive to light olive gray. Patches of calcite. Bryozoans.
45'	12"	Coarse grained fossil fragments, some massive Tetradium sp. in life position in this interval. Matrix very fine grained to coarse grained. Bryozoans prominent also brachiopods (Zygospira sp.), crinoid columnals and gastropod fragments. Some shale partings. Some cross bedding. Sample P-75: About 1 inch below top of interval. Sample P-75A: Picked along same interval, typical of non-Tetradium bearing rock. Sample P-76: Top 3". Bryozoans weathering on surface, crinoid fragments mostly fine grained. Tetradium fragments filled with very fine grained. May be silica replaced.
45'5"	5"	Very fine to coarse grained limestone with chert replacing limestone in patches and completely in the top about 1 1/2 to 2 inches. Some fossil fragments may be Tetradium in this T-4 Chert. Intraclasts, brachiopods, and bryozoans observed. Sample P-77

Cum.	Thickness Interval	Description
48'11"	42"	Covered (this interval included as estimated three feet of bentonite.)

Note: next beds slightly slumped. There is some question about whether it is in place. Lithology, that of "Carters Type"; as opposed to Hermitage Formation above. My estimate is that it is very near being in place.

49'3"	4"	Brownish gray (5YR4/1) to brownish black (5YR2/1), mostly very fine grained with close to pale yellowish brown (10YR6/2) mottling filled with fine grained material, probably vertical burrows. Fossil fragments scattered, brachiopods and probably bryozoans. Some chert. Sample P-78: (Note: vertical burrows to interface with above lithology).
49'6"	3"	Coarse grained with very fine and fine grained matrix, color between pale yellowish brown (10YR4/2). Some brachiopods filled with white calcite. Sample P-79
50'5"	11"	Approximately same lithology as below. Fossil concentrations (coarse grained in very fine grained matrix, top few inches), lower part finer-grained, light yellowish brown with brownish black chert abundant.
50'8"	3"	Calcareous shale and shaly limestone (mostly) very fine grained beds about 1/2 inch thick with shale partings, yellowish gray near top. Sample P-80
50'11 3/4"	3 3/4"	Brownish gray, very fine grained with some mottling. Birdseyes near top of interval, also calcite filling fractures and partially filling widely scattered fossils. Fossils also have mud filling. Sample P-81: Bottom 1 1/4" Sample P-82: Top 1 1/2".
51 3/4"	1"	Very fine grained along bottom then covered by fossil fragments, brachiopods filled with calcite.
52'2 3/4"	14"	Very fine grained, pale yellowish brown (10YR6/2) to dark yellowish brown (10YR4/2) with dusky yellowish green (10GY3/2) patches. Some dark brown near top where it becomes shaly. Isolated birdseyes observed, also brachiopods filled with white calcite. Some vertical mottling. Sample P-83

Cum.	Thickness Interval	Description
52'7 3/4"	5"	Very fine grained matrix pale yellowish brown (10YR6/2) and dark yellowish brown. Sparry calcite filling brachiopods, etc. Other unidentifiable fossils scattered in this interval. Sample P-84: Top 2".
52'10 1/4"	2 1/2"	Very fine grained, pale to dark yellowish brown, fine grained black patches, probably vertical burrows filled with (Hermitage lithology) the overlying sediments, coarse constituents consist of fossils.

Note: No marked erosional surface, marked color change.

TOP OF CARTERS LIMESTONE, UPPER MEMBER

SUBSEQUENT UNITS LOWER PART OF HERMITAGE FORMATION

Cum.	Thickness Interval	Description
53'1/4"	2"	Fetid limestone, fine to coarse grained, brownish black (5YR2/1). Abundant fossil fragments, brachiopods, etc. Sample P-86: Just above Sample P-85.
54'1/4"	12"	Fine to coarse grained, brownish black limestone, some brachiopods filled with white sparry calcite, some bryozoans. Weathered surface very irregular.
54'2 1/4"	2"	Coarse grained fossils and fossil fragments filled with sparry calcite, brachiopods, bryozoans, etc. Sample P-87
54'3 1/2"	1 1/4"	Fine to coarse grained (various sizes in coarse fraction), some large patches of sparry calcite probably filling large brachiopods, cystoid or crinoid columnals. Sample P-88A: Example of fossils.
54'6 1/2"	3"	Fine to coarse grained with coarse fraction being mostly unidimensional, about three millimeters.
54'8 1/2"	2"	Fine to coarse grained, mostly unidimensional, about 3 mm with larger calcite patches. Sample P-88: Bottom 1/2.
54'10 1/2"	2"	Very coarse grained. Sample P-88A

Thickness Cum.	Interval	Description
55'3"	4 1/2"	Coarse grained, mostly unidimensional, about three millimeters with some large calcite patches. Sample P-89
55'7"	4"	Very coarse, various size fragments in irregular bedding. Patches of white sparry calcite. Sample P-90
55'9"	2"	About the same as lithology below it, some very fine grained matrix, crinoid columnals and gastropods.
56'4 1/2"	7 1/2"	Fine to coarse grained, dark brownish gray, fetid limestone. Abundant fossil fragments, crinoid columnals, brachiopods. Large patches of sparry calcite filling orthocone cephalopod. Some patches of fine grained limestone. Sample P-91
58' 1/2"	20"	Fine to coarse grained with coarse grains being unidimensional, about 2 to 3 millimeters. Sample P-92
58'2 1/2"	2"	Coarse grained mostly brachiopod fragments. Sample P-93

MILL BRANCH SECTION

Melvine quadrangle, Tennessee, 7.5 minute series, Topographic 110-NE (1956); Geologic GM 110-NE, Milici and Coker (1967). See Figure 1, page 4, for location. The base of the section is about 3,100 feet southeast of the confluence of Mill Branch and the Sequatchie River and 4,000 feet southwest of Red Hill Church and extends southeastward along the southwest side of Mill Branch for about 350 feet. (Tennessee Coordinates 467,800N., 2,271,500E. to 466,900N., 2,272,100E.)

UPPER PORTION OF CARTERS LIMESTONE, LOWER MEMBER

Thickness Cum.	Interval	Description
5"	5"	Dark to dusky yellowish brown, very fine grained to fine grained limestone. Some calcite, also fine mottling, possibly burrows, pale yellowish brown to yellowish gray and mostly horizontal. Sample MB-1
5 3/4"	3/4"	Fine grained with brownish black chert, irregular surfaces on chert. Sample MB-1A
8 1/4"	2 1/2"	Fine grained to very fine grained, dark yellowish brown limestone with pale yellowish brown, fine grained burrow mottling. Sample MB-2
11"	2 3/4"	Mostly fine grained, horizontal burrows with some very fine grained in horizontal layers with irregular bedding plane at the top of the interval. Sample MB-3
1'6 3/4"	7 3/4"	Brownish gray to olive gray, very fine grained to fine grained, some coarse, possibly small crinoid columnals. Fine grained light olive gray (5Y5/2) burrows. About 5 inches from the base of the interval chert observed that varies from 1/2 to 2 inches in thickness to absent. The chert was observed along outcrop about 100 feet wide. It has irregular top and bottom surfaces and is a brownish black to olive black color. Abundant fossils in chert. Sample MB-4
1'7 1/4"	1/2"	Irregular, thin-bedded, coarse fossil fragments. Bryozoans, brachiopods, or pelecypods in a very fine grained matrix.
1'11 1/4"	4"	Very fine grained, dark yellowish brown filling burrows which are mostly horizontal.
2'2 3/4"	3 1/2"	Very fine grained, dark yellowish brown to dusky yellowish brown with pale yellowish brown fine grained diagonal, horizontal and vertical burrow mottling. Other fossils rare. Sample MB-5
3'10 3/4"	20"	Very fine grained, dark yellowish brown to dusky yellowish brown with fine grained, pale yellowish brown filled burrows mostly horizontal; cup coral observed. Near top, dark almost black surface in conjunction with burrows. Sample MB-6: Top few inches.

Cum.	Thickness Interval	Description
4'5"	6 1/4"	Very fine grained to fine grained, between dark and dusky yellowish brown limestone with irregular fine grained partings, mostly dusky yellowish brown about every 1 1/2 inches. Burrows may be along this parting. Small 2 mm calcite patches and fossil fragments. Sample MB-7
5'	7"	About the same as MB-7 except more pale yellowish brown, fine grained burrows; color probably due to weathering. Crinoid columnals and brachiopod fragments observed. Sample MB-7A
6'	12"	Very fine grained, dark to dusky yellowish brown with fine grained partings. Dark to black, irregular separtions (possibly algal mats); some calcite patches, may be small fossils or fragments, about 2 mm, some a little larger. Sample MB-8: Bottom 2" of bed.
6'6"	6"	Olive gray (5Y4/1) very fine grained to mostly fine and coarse grained. Patches of calcite filling (?) brachiopods. Brachipod molds, bryozoan, crinoid columnals and rugose cup coral. Sample MB-9
6'11"	5"	About the same as below except irregular partings. Some indication of burrowing. Sample MB-10
7'5"	6"	Close to dark yellowish brown, very fine grained with patches of calcite possibly fragments of fossils. Fine grained mottling approximately yellowish gray. Sample MB-11
7'11 1/2"	6 1/2"	Very fine to fine grained near bottom becomes coarse grained upward. Olive gray, somewhat laminated, fossil fragments about 1 mm (average). Some brachiopods and cephalopods or coral. Top of interval fine to very fine grained. Sample MB-12: Bottom 2 1/2".
8'7 1/2"	8"	Dark to dusky yellowish brown, suggestion of brownish gray bottom 2 to 3 inches, very fine grained with irregular partings filled with dark reddish brown to brownish black fine grained material, gets more pale yellowish brown near top. Some coarse fossils mostly silica replaced jumbled crinoid columnals. Sample MB-13: Top 4".

Cum.	Thickness Interval	Description
8'9 1/2:	2"	Very fine grained matrix with coarse fossils and fragments mostly crinoid columnals between dark and dusky yellowish brown burrows mostly in vertical position fine grained and a pale yellowish brown color. Sample MB-14
9'1 1/2"	4"	Color more dusky yellowish brown, mostly fine grained with some coarse fossil fragments, crinoid and ostracod debris, some fine grained filled burrows (?).
10'5"	15 1/2"	Very fine grained, brownish gray with mostly horizontal, fine grained partings about 1/2 inch apart at bottom to 1 inch separation at top. From about 8 inches to 10 inches above the base brownish black chert in nodules about 1/2 inch thick, but sometimes 10 inches wide; chert also replacing bryozoans. Sample MB-15: Top 2 1/2". Sample MB-15A: Chert.
10'9"	4"	Very fine grained, close to dusky yellowish brown with light olive gray mottling. Brachiopod fragments, patches of sparry calcite probably replacing crinoid columnals. Sample MB-16
10'10"	1"	Very fine grained, dusky to dark yellowish brown, patches of calcite.
11'	2"	Coarse grained, mostly fossils and fragments in a very fine grained matrix. Chert, with patches of fine grained in chert, which is mostly very fine grained. In the top 2 inches becomes coarse grained. Fossils on weathered surface (brachiopods, crinoids columnals, etc.) Parting about midway with brownish black surface. Chert is extensive in this interval, not always at the same horizon. Some fine grained burrow mottling. Sample MB-17
11'5 1/2"	5 1/2"	Very fine grained, olive gray to brownish gray matrix with light olive gray, fine grained mottling, with coarse fossils (bryozoans, brachiopods, etc.); near top of interval more fossils (abundant bryozoans) are silicified in a 2 inch band of chert. Sample MB-18A
11'8 1/2"	3"	Very fine grained to fine grained, olive gray limestone which has olive black chert layers and lenses.

TOP OF CARTERS LIMESTONE, LOWER MEMBER

SUBSEQUENT UNITS PART OF CARTERS LIMESTONE, UPPER MEMBER

Thickness Cum.	Interval	Description
16'8 1/2"	48-60"	Covered (estimate that about 36 inches of this interval is T-3 bentonite.)
17'3 1/2"	7"	Very fine grained, olive gray to light olive gray apparently laminated. Patches of calcite some of which are possibly interlamina. Larger calcite patches, about 1/4 inch across, possibly filling fossils or vugs. Suggestion of mud cracks on weathered surface. Sample MB-19
17'11 1/2"	8"	Much like the lithology below, perhaps a few more birdseyes randomly oriented. Possible mud cracks on outcrop surface with polygon from 1 to 1 1/2 inches across. Sample MB-20
18'4 1/2"	5"	Laminated, argillaceous possibly dolomitic limestone (?), light olive gray (5Y5/2) dusky yellow (5Y6/4), fine to coarse grained, intraclasts due to breakup of desiccation features. Abundant birdseyes. Large mud cracks about 3 to 4 inches across. Sample MB-21
20' 1 1/2"	32"	Light olive gray to yellowish gray, calcareous fine grained siltstone with lenses of light olive gray, very fine grained limestone in depressions on irregular surfaces. Large mud cracks with 1/4 inch separation in some cases. Overlies 21" covered interval. Sample MB-22
22' 1/2"	12"	Olive gray to light olive gray, very fine grained alternating with fine grained laminations in bottom few inches. Near top becomes more fine grained, small mud crack polygons (1/2 to 1 inch) with crack separations of 1/8 to 1/4 inch. Some polygons are 2 to 3 inches across. Round birdseyes or mottling 1/4 inch diameters. Sample MB-23 Sample MB-23A
23' 1/2"	12"	Covered (float similar to lithology below).
23'8 1/2"	8"	Light olive gray to olive gray, very fine grained (looks silty) with laminations. Some with interlamina calcite birdseyes that are elongate horizontal. Mud cracked. Sample MB-24

Cum.	Thickness Interval	Description
24'5 1/2"	9"	Light olive gray (5Y5/2), very fine to fine grained, irregular laminations of argillaceous or dolomitic limestone with abundant interlamina birdseyes. Also vertical patches of calcite, probably filling mud cracks. Mud crack polygons on weathering are 1 to 2 inches across. Sample MB-25
25'3 1/2"	10"	Light olive gray, very fine grained mudstone, or dolomitic limestone, with abundant birdseyes between irregular lamination and along small scale vertical cracks. (Note box pattern on MB-26.) Some brownish black stains. Sample MB-26
26'9 1/2"	18"	Covered
29'1"	27 1/2"	Olive gray to light olive gray mudstone, very fine to fine grained, laminated. Birdseyes. Dark brownish black dendrites and patches on broken surfaces, or mud cracks. (No polygons observed, possibly very large.) Sample MB-27
29'7 1/2"	6 1/2"	Grayish olive or possibly between light olive gray (5Y5/2) and olive gray (5Y3/2), very fine grained dolomitic mudstone or argillaceous limestone. Suggestion of laminations. An occasional small birdseye (?) less than 1 mm. Dark brownish black stains.
29'10"	2 1/2"	About the same as interval below except more dense (less weathered). Birdseyes larger, about 1/4 inch across. Sample MB-28
30'8"	10"	Brownish gray, very fine grained matrix with abundant coarse fossils and fossil fragments. Large black object may be birdseye. Some suggestion of burrowing. Sample MB-29: 1" to 3" bed near bottom. Sample MB-29A
31'1"	5"	Light olive gray (5Y5/2), very fine grained dense limestone with coarse fossil and fossil fragments. Crinoid columnals, Tetradium, ostracods, bryozoans, weathering out on surface. Thin beds 1/2 inch or so thick toward top of interval. Maybe some horizontal burrows. Sample MB-30
31'6"	5"	Light olive gray with greenish gray mottling, very fine grained with coarse fossils. Bryozoans, ostracods or pelecypods, and brachiopods on weathered surface. Sample MB-31

Cum.	Thickness Interval	Description
31'10 1/2"	4 1/2"	Laminated limestone, olive gray, very fine grained and fine grained. Laminations about 1/4 inch thick. Sample MB-32 Sample MB-32A
32'2"	3 1/2"	Olive gray to olive black, coarse grained, some very fine grained matrix, maybe intraclasts between yellowish brown and dark yellowish brown. Fossils and fossil fragments abundant, mostly fragments of brachiopods and abundant crinoid columnals. Sample MB-33
32'9"	7"	Coarse grained with patches of calcite filling fossils or voids. Very fine grained matrix. Sample MB-34
32'11 1/4"	2 1/4"	Fine and very fine to coarse fossils and fragments, dark yellowish brown. Fine grained near top, ripple marked. Cross bedding. Sample MB-36: Bottom. Sample MB-37: Top.
33'1/2"	1 1/4"	Very fine to fine grained, close to dark yellowish brown laminated and cross laminated with coarse to fine grained, graded coarse to fine bottom to top. Brachiopod fragments. Sample MB-38
33'3 1/2"	3"	Olive gray to light olive gray with dark fragments of coarse grained fossils with fine to very fine grained matrix, has laminated appearance and greenish gray mottling. Large patches of calcite and silica replaced fossils filling scour or ripple marks. Sample MB-39
33'5 1/2"	2"	Between pale yellowish and dark yellowish brown, coarse grained with very fine grained to fine grained matrix. Patches of calcite filling brachiopods, bryozoans, etc. Sample MB-40
34'1/2"	7"	Brachiopods, bryozoans, Tetradium in very fine grained matrix between brownish gray and olive gray. Some concentrations of mostly coarse grained. Fossil fragments. Sample MB-41
34'6 1/2"	6"	Very fine grained limestone between brownish gray and olive gray. Brownish black chert in nodules and replacing bryozoans, Tetradium (?), brachiopods (Zygospira sp.), etc. Tetradium appearing to be in life position. Sample MB-42: Note Tetradium sp. Sample MB-43

Cum.	Thickness Interval	Description
34'8 1/2"	2"	Chert brownish black.
37'8 1/2"	36"	Covered, slumped blocks have lithology similar to that of upper Carters and Lower Hermitage elsewhere in the study area.
38'6 1/2"	10"	Shaly limestone very fine grained to fine grained, close to brownish gray color. May be laminated. Sample MB-44: Weathered Sample MB-44A
38'7 1/2"	1"	Bed of very fine to fine grained, cross laminated, olive gray (5Y4/1) limestone. Sample MB-45
39'9 1/2"	14"	Shaly limestone. Very fine grained, close to light olive gray (5Y5/2) color. Suggestion of lamination. Sample MB-46
40'	2 1/2"	Very fine grained, olive gray possibly mud cracked. Some birdseyes filling vertical (burrows?) cracks. Sample MB-47

TOP OF CARTERS LIMESTONE, UPPER MEMBER

SUBSEQUENT UNITS LOWER PART OF HERMITAGE FORMATION

Cum.	Thickness Interval	Description
40'9"	9"	Fine grained brownish black to dark yellowish brown. Fine grained with some fossil fragments and fossils filled or replaced with calcite. Sample MB-48 Sample MB-48A
41'11"	14"	Brownish gray to brownish black nodular appearing coarse grained limestone. Large brachiopods, bryozoans, etc. Sample MB-49
42'2"	3"	Coarse grained, more unidimensional (about 1/2 inch average size of grains) than interval below and not nodular. Patches of calcite about 3/4 inch long filling brachiopod (?). Sample MB-50

Thickness Cum.	Interval	Description
43'6"	16"	Coarse grained about the same as sample MB-49 below. Large (1 1/2 inch) strophomenid brachiopods make up most of rock. Also bryozoans. Sample MB-51A: Brachiopod sample.
43'10"	4"	Coquinoid limestone, coarse grained, same color as below except more white calcite. Crinoid columnals, some smaller brachiopods (?) or fragments. Sample MB-52
44'4"	6"	Covered, according to measurement from datum bed, beds below on erosional remnant those above on outcrop.
45'5"	13"	Mostly fine grained to coarse grained, almost dusky yellowish brown. Weathers nodular. Sample MB-53
45'9"	3 1/2-4"	Coarse grained, dark to dusky yellowish brown fossils and fragments. Brachiopod and crinoids abundant, some clear and white sparry calcite. Sample MB-54
47'9"	24"	Pale yellowish brown to brownish black, very fine to coarse grained. Uneven bedded fossil fragments of abundant bryozoans, brachiopods, and possible trilobite debris.
48'10"	12-13"	Massive bed of brownish black coarse limestone with large calcite (white) patches filling brachiopods, curved cephalopods, and cup coral. Sample MB-56: Bottom 9" Sample MB-56A

HOWARD CEMETERY SECTION

Mount Airy Quadrangle, Tennessee, 7.5 minute series, Topographic 104-NE (1946, Revisions 1966). The base of the section is about 700 feet northeast of Howard Cemetary on the north side of the unnamed stream and about 400 feet from where the stream enters the Sequatchie River (Tennessee Coordinates 399,000N., 2,219,500E. to 398,700N., 2,219,700E.)

UPPER PORTION OF CARTERS LIMESTONE, LOWER MEMBER

Thickness Cum.	Interval	Description
6 1/2"	6 1/2"	Very fine grained, dark yellowish brown limestone with fine grained, light tan, yellowish gray (5Y7/2) vertical and horizontal mottling (burrows). Some small calcite patches in very fine grained fraction. Cup coral observed. Sample HC-1
11"	4 1/2"	Very nearly same lithology as that below. Burrow mottling not as abundant. Fossil coral. Sample HC-2
2'	13"	Very fine grained, dark to dusky yellowish brown with fine grained, yellowish gray mottling, mostly horizontal. Crinoid columnals, rugose coral, bryozoans observed. Above 2 inches of this interval intensely burrowed. About 3 inches from top of interval olive black chert in discontinuous layer which can be traced across the outcrop for several feet. Above chert many fine-grained yellowish gray (5Y7/2) burrows mostly horizontal in very fine grained matrix. Some fossils which may be crinoid columnals. Sample HC-3; Bottom 3". Sample HC-4A
2'2 1/4"	2 1/4"	Very fine to coarse grained limestone, coarse fraction mostly fossils and fragments of fossils observed. Fossils are crinoid columnals, cup corals, brachiopods, and orthocone cephalopods. Fine grained, yellowish gray parting with orthocones or intraclasts. Sample HC-5
2'4"	1 3/4"	Very fine grained, olive gray limestone with horizontal fine grained, light olive gray mottling (burrows). Some very fine to coarse fossils and fragments. Brachiopods and crinoid columnals observed. Sample HC-6
2'11 1/4"	7 1/4"	Mostly fine grained with scattered coarse grains (fossil fragments) with some vertical and horizontal fine-grained burrow mottling.
3' 1/4"	1"	Coarse grained brachiopod, crinoids, and other fossils and fragments. About 1/2" fine grained, yellowish gray burrow mottling in very fine grained matrix. Sample HC-8

Cum.	Thickness Interval	Description
3'7"	6 3/4"	Very fine grained, dark yellowish brown (10YR4/2) with fine grained (probably light olive gray before becoming weathered to more orange color) burrow mottling mostly horizontal but some vertical. Fewer burrows at top of interval. Fossil fragments concentrate in zone near top. Sample HC-9
3'9"	2"	Mostly fine grained, light olive gray.
4'3"	6"	Dark to dusky yellowish brown, very fine to fine grained, light olive gray, fine grained burrows in about 1 inch layers mostly horizontal at about 2 inch intervals. Chert nodules about 1 inch across observed. Sample HC-10
5'5"	14"	Very nearly the same lithology as unit below. The fine grained burrow mottling is quite continuous along the outcrop. About 11 1/2 inches from the base of the interval brownish black chert 1 inch and less is observed in discontinuous layers.
5'7 1/2"	2 1/2"	Covered.
6'1 1/2"	6"	Fine to very fine grained, little darker than dark yellowish brown. Scattered patches of white calcite. Layer of brownish black chert fairly continuous along same horizon (pinches out after 6 to 10 inches). Thin shale partings about 1/8 inch each laminated to cross laminated as seen by dark fine grained particles. Sample HC-11: Top 2". Sample HC-11A
6'2" 1/2"	1"	Fine to coarse grained limestone. Coarse fraction of fossils and fragments of fossils.
7'5 1/2"	15"	Dark to dusky yellowish brown mostly fine grained with very fine grained. Scattered fossils (brachiopods) about 3 inches from base of interval 1 inch chert layer in almost all of the outcrop at the same horizon. Irregular concentrations of chert observed above layer of chert. Sample HC-12
7'10"	4 1/2"	Mostly fine grained to coarse grained dark yellowish brown with patches of sparry calcite and light olive gray mottling. At least 2 dark brown to black partings which may be stylolites or algal mats. Some cross laminations in fine to very fine grained fraction. Sample HC-13

Thickness Cum.	Interval	Description
8'4"	6"	Fine to coarse grained limestone. Coarse fraction consists of fossils and fragments.
9'4"	12"	Very coarse grained limestone with much sparry calcite, fossils and fragments of fossils include brachiopods, crinoid columnals, cup coral, bryozoans, orthocone cephalopods, tabulate coral. Top of outcrop weathers very rough. Silica replacing fossils. Beekite rings observed. Sample HC-14: Top 10". Sample HC-15: Tabulate coral. Sample HC-16
9'11"	7"	Dark yellowish brown (10YR4/2) mostly very fine grained with light olive gray mottling, fine grained vertical and mostly horizontal burrow mottling. Irregular brownish black to black partings which persist along the outcrop. Fine grained material also associated with partings. Crinoid columnals on weathered surface. Patches of sparry calcite probably filling fossils. Sample HC-17
10'9"	10"	About same lithology as below except more patches of calcite at several levels. Possibly concentrations of fossils. Parting in massive bedding at the top of this interval. Sample HC-18
11'5"	8"	Fine to coarse grained mostly fine grained. Not much evidence of burrows. Grains more like fossil fragments of smaller size. Some large patches of calcite. Fine grained stringers can be traced across outcrop. Sample HC-19
12'3"	10"	Very fine grained to fine grained, dark yellowish brown with some coarse grains. Much like HC-17. The light olive gray, fine grained burrow mottling more intense upward thus the fine grained fraction increases toward the top. Crinoid and cup coral observed. Vertical and mostly horizontal burrows weathering. Top of massive bed. Sample HC-20: Top 2".
12'6"	2 1/2-3"	Very fine grained, dark yellowish brown with fine grained, light olive gray mottling and fossil fragments. Irregular fine grained parting with intraclasts (?). Sample HC-21

Cum.	Thickness Interval	Description
12'9 1/2"	3 1/2"	Dark yellowish brown, very fine grained with fine grained, light olive gray burrow mottling. One inch zone of coarse fossil fragments in center of interval. Some chert in irregular layers 1/2 inch thick. Sample HC-22
12'11 1/2"	2"	Covered.
13'3 1/2"	4"	Dark yellowish brown, fine to coarse grained and very fine grained with fine grained, light olive gray burrow mottling.
13'6"	2 1/2"	Coarse grained fossils and fragments of fossils and white sparry calcite, some very fine grained nodular appearing areas. Fossils: brachiopods, crinoid columnals, and cup coral. Sample HC-23
14'5"	11"	Mostly very fine and fine grained dark yellowish brown some coarse fossil fragments in a narrow zone. Much burrow mottling. Sample HC-23
15'1"	8"	Very fine to coarse grained in a very fine grained matrix. Irregular chert nodules along center of bed. (Note: fine grains in chert.) Cup corals, bryozoa, brachiopods, and possibly gastropods. Sample HC-24
15'3 3/4"	2 3/4"	Coarse to fine grained fossil fragments, pale and dark yellowish brown fragments mostly crinoid columnals, brachiopod weathering out on surfaces. Sample HC-25 Sample HC-25A
15'8 1/4"	4 1/2"	Very fine grained, dark yellowish brown with patches of coarse fossil fragments and fossils. Chert in small patches probably filling fossils. Bryozoans, brachiopods, ostracods (?), gastropods weathering out on surface. Sample HC-26
15'11 1/4"	3"	Thin irregular beds of limestone about 1/2 inch thick, light olive gray (5Y5/2) very fine grained matrix with coarse layers and patches.

Cum.	Thickness Interval	Description
16'3 3/4"	4 1/2"	Very fine grained, pale to dark yellowish brown with coarse fossils and fragments of fossils running through in about 1/2 inch zones. Apparently some burrows weathering out on surface. Sample HC-27
16'6 1/2"	2 3/4"	Very fine grained with light olive gray mottling with irregular chert underlying coarse grained layer. Sample HC-28A
16'9 1/2"	2 1/2-3"	Grayish black chert replacing coarse fossil debris including brachiopods, Zygospira sp., lithology similar to underlying unit. Sample HC-29 Sample HC-29A: Includes part of underlying unit.

TOP OF CARTERS LIMESTONE, LOWER MEMBER

SUBSEQUENT UNITS PART OF CARTER LIMESTONE, UPPER MEMBER

Cum.	Thickness Interval	Description
18'2 1/4"	16 3/4"	T-3 Bentonite, pale blue-green (5BH7/2) fairly fresh
18'5 3/4"	3 1/2"	Limestone, yellowish gray to grayish green, very fine to coarse grained. Sample HC-29B
18'9 3/4"	4"	(?) Reworked T-3 Bentonite.
19'1 1/2"	3 3/4"	Limestone, yellowish gray course grained, brachiopod or ostracod fragments.
19'3"	1 1/2"	Bentonite, reworked (?).
19'4 1/2"	1 1/2"	Limestone, coarse grained fossil fragments.
19'6 1/2"	2"	Mostly coarse grained with large (1 1/2 inch) brachiopods filled with white sparry calcite. Pale yellowish brown with much white calcite, some grayish green (10GY5/2) patches and stringers about 1 inch from bottom. Galena. Sample HC-30

Cum.	Thickness Interval	Description
19'10"	3 1/2"	Above a grayish green parting with fossils and fragments, pale yellowish brown mixed with white calcite. Very fine grained patch (shale or laminated limestone pebble) abundant brachiopod and crinoid fragments.
20'	2"	Coarse grained limestone brachiopod (ostracod?). Light olive gray to medium light gray, very fine grained matrix. Some clear silica. Red jasper replacing fossil patches of white calcite, high spired gastropods. Sample HC-31 Sample HC-31A
20'1 3/4"	1 3/4"	Clay shale light olive gray (5Y5/2). May be reworked bentonite. Sample HC-34A
20'4 1/2"	2 1/2"	Coarse grained limestone close to light olive gray (5Y5/2) with fine grained matrix mostly brachiopod, ostracod, pelecypod and gastropod fragments. Much white sparry calcite observed. Valves of fossils appear to be nested. Sample HC-32
20'5 3/4"	1 1/2"	Very fine grained light olive gray (5Y5/2) matrix with abundant brachiopods (ostracods?) or pelecypods. Sample HC-33
20'8 3/4"	1 1/2-3"	Shale, light olive gray with some slit. Sample HC-34
20'10"	1 1/4"	Calcareous shale, light olive gray (5Y5/2), weathers light olive brown (5Y5/2) and moderate yellow (5Y7/6). Sample HC-35
20'11 1/2"	1 1/2"	Grayish olive (10Y4/2) very fine to fine grained laminated argillaceous limestone, patches of green about 2 mm diameter scattered throughout. Sample HC-36
21'4 1/2"	5"	Very fine grained dark yellowish brown and grayish olive alternating with coarse grained fossils and fragments in very fine grained matrix. Chert in layers seems to be associated with coarse grained layers. Fossils consist mostly of brachiopods. Sample HC-37A

Cum.	Thickness Interval	Description
22'5 1/2"	5"	Very fine grained, dark yellowish brown with patches of calcite both horizontal and vertical. Seem to be associated with mud cracks and laminations near top. Signs of mud cracks on surface filled with calcite. Mud crack polygons about 1 1/2 inch across. Unit weathers very pale orange (10YR8/2) to grayish orange (10YR7/2).
22'5 1/2"	8"	Shaly limestone appears to be highly mud cracked on weathered surface. Beds 1/2 inch to 3/4 inch thick and laminae much thinner. Some calcite between laminae. Two lithologies very fine grained and very fine grained with calcite. Sample HC-38 Sample HC-38A
22'9"	3 1/2"	Laminated argillaceous limestone or dolomitic limestone, olive gray with mud cracks, vertical patches of calcite near top of interval filling mud cracks. Birdseyes interlamina. Sample HC-39: Bottom. Sample HC-39A: Top.
23'1"	4"	Laminated argillaceous limestone or dolomitci limestone, olive gray. Calcite between laminations. Mud cracks with polygons about 3 inches across, birdseyes in vertical mud cracks. Sample HC-40
23'1 1/2"	1/2"	Same lithology as below, smaller polygons about 1/2 inch across filled with calcite.
23'8 1/2"	7"	Alternation of about 1 inch of very fine grained then about 1 inch of laminated dolomitic limestone with calcite between laminations. Sample HC-41
23'9 1/2"	1"	Olive gray to light olive gray limestone. Intraclasts of a composition similar to underlying lithology. Sample HC-42
24'1/2"	3"	Very fine grained with patches of white calcite following fractures (note bottom of sample). Mud crack polygons about 2 inches across. Sample HC-43

Cum.	Thickness Interval	Description
24'2 1/2"	2"	Fine to coarse grained limestone, calcite patches (?) maybe filling fossils, light olive gray intraclasts about pebble size.
24'3 1/4"	3/4"	Shaly parting with underlying unit then olive gray limestone or dolomite (?) with calcite between laminations. Sample HC-44: At top of outcrop.
24'5 3/4"	2 1/2"	Very fine to fine grained laminated, close to dusky yellow (5Y6/4) and darker in places. Calcite between some laminations. Sample HC-45
25'1 3/4"	8"	Yellowish gray (5Y7/2) and dusky yellow (5Y6/4) mudstone (dolomite?) with small dark yellowish brown (10YR4/2) dendrites. Weathers yellowish gray (5Y7/2) to grayish yellow (5Y8/4) deep mud cracks on weathered surface. Average polygon about 1 1/2 to 2 inches across and weathers rounded. Sample HC-46: Top few inches of 11" bed.
25'8 3/4"	7"	Alternation between mudstone with laminations and dendrites and very fine grained, olive gray limestone with calcite patches. Mud cracks prominent forming polygons which average 1 inch across. Sample HC-47
25'10 3/4"	2"	Olive gray (limestone?) very fine to fine grained with brownish red and some calcite patches (birdseyes).
25'11"	1/4"	Siltstone laminated with dark dendrites.
26'1 1/4"	1 1/4"	Very fine grained argillaceous limestone or dolomite with vertical and horizontal patches of calcite. Sample HC-48
26'1 1/4"	1"	Intraclastic limestone with very fine grained matrix. Calcite along mud cracks. Sample HC-48A
26'11 1/4"	10"	Yellowish gray argillaceous or dolomitic limestone laminated or cross laminated. Dark colored dendrites, lenses of olive gray with interlamina birdseyes about 1 mm diameter, fewer lenses near bottom of interval. Sample HC-49: Top 3-4".

Cum.	Thickness Interval	Description
27'4 3/4"	5 1/2"	Olive gray to light olive gray, very fine grained argillaceous limestone with 1/2 to 1/4 inch calcite patches running through, weathering surface exhibits mostly horizontal rounded grooves. Some what appear to be vertical mud cracks but may be due to fracture. Sample HC-50
28'1/4"	7 1/2"	Olive gray argillaceous or dolomitic limestone laminated. With lenses or laminations containing birdseyes between laminae surfaces. Mud cracked. Rounded weathered surfaces are contoured with lamina. Sample HC-51
28'10 1/4"	10"	Shaly weathering argillaceous limestone about the same lithology as unit below. Two inch bed in middle of unit very fine grained mostly light olive gray with interlamina calcite. Where calcite is abundant, color darker. Sample HC-52: 2" bed in middle of unit.
29'2 1/2"	4 1/4"	Light olive gray (5Y5/2) very fine grained mudstone no laminations that can be traced. Sparse calcite in fractures or mud cracks. Top of bed gastropod fossils and (?) intraclasts. Sample HC-53 Sample HC-53A
29'10 1/2"	8"	Covered.
31'4 1/2"	18"	Olive gray to light olive gray (5Y5/2), very fine grained serves as matrix for lenses of very fine grained. Interlamina birdseyes or fossil fragments and intraclasts. Sample HC-54
31'5 1/2"	1"	Thin bedded very fine grained shaly weathering limestone. Some laminations.
31'7 1/4"	1 3/4"	Olive gray to light olive gray, very fine grained limestone, a few laminations and patches of very fine grained, light olive gray. Sample HC-55
31'9 1/4"	2"	Very fine grained, light olive gray with lenses and stringers of coarse grained. The coarse fraction seems to be associated with a mat-like substance (something like lacy bryozoans). Fine grained layer near the top with crinoid columnals, parts of brachiopod shells, and mats. Sample HC-56 Sample HC-56A: Near top.

Cum.	Thickness Interval	Description
32'1/2"	3 1/4"	Very fine grained, moderate olive brown and light olive gray (5Y5/2) some fine grained lenses, thin laminations and possible cross laminations. Sample HC-57: Bottom 1 3/4". Sample HC-58: Top 1/2".
32'2 1/2"	2"	Very fine grained along bottom of bed. Fine grained to top with rare calcite patches. Brachiopod (?) filled with sparry calcite, cross laminations of fine grained. Light olive gray mottling. Sample HC-59
32'4 1/2"	2"	Very fine grained, close to moderate olive brown with some birdseyes and fine to coarse material. Brachiopods filled with calcite. Cross laminated, some mud cracks. Sample HC-60
		Next two feet weathers very shaly to between grayish yellow (5Y8/4) and pale greenish yellow (10Y8/2). Gives the appearance of being highly mud cracked with 1/2 to 1 inch polygons.
33'2 1/2"	10"	Very fine grained argillaceous limestone, grayish olive (10Y4/2) with grayish brown to moderate brown stains and dendrites. Occasional birdseyes and lenses of trilobite or brachiopod fragments in the very fine grained matrix. Seems to get more crossbedded or laminated near top. Fractures filled with moderate reddish brown (10Y4/5) filling. Sample HC-61 Sample HC-62 Sample HC-62A Sample HC-62B
34'	9 1/2"	Grayish olive, very fine grained argillaceous (shaly) limestone with brown to moderate brown stains. Thin bedded 1/4 to 1/2 inch. Sample HC-63
34'7"	7"	Same color as below, very fine grained argillaceous limestone. Mud cracks on surface. Gets more laminated with some small patches of coarse intraclasts near top. Sample HC-64 Sample HC-64A: Top of interval.
35'1"	6"	Olive gray with brown stains (dendrites) along fractures, coarse patches of fossils, trilobite debris and Tetradium fragments, irregular laminations observed. Large mud cracks. Sample HC-65A Sample HC-65

Cum.	Thickness Interval	Description
35'8 3/4"	7 3/4"	Olive gray (5Y4/1) with moderate brown (5YR3/4) to dusky brown (5YR2/2) stain. Very fine grained matrix with light olive gray coarse grained particles 1/2 to 3/4 inch across in lenses. Interlamina birdseyes, may be fossil fragment filled with calcite; possible brachiopods. Bedding about 1/2 inch average. Near top concretion-like mass with grayish red (5R4/2) to dusky red (5R3/4) color. Some small patches of clear calcite. This interval is a massive bed which persists along strike, and contains Tetradium, sp. extensively. Sample HC-66: Bottom. Sample HC-67: 4 1/4 inch above base. Sample HC-68: About 5" from base. Sample HC-69: Top.
35'11 3/4"	3"	Brownish gray (5YR4/1) with greenish gray (5GY6/1) fine to coarse grained. The coarse fraction consists mostly of Tetradium fragments and brachiopods. About 1 3/4 inches very fine grained with mottling at the top. Patches of clear and white calcite with bryozoans. Sample HC-70: Bottom 3".
36'7 3/4"	8"	Brownish gray with greenish gray, very fine grained with coarse stringers and patches of brachiopods including Zygospira, sp. Sample HC-71
36'9"	1 1/4"	Very fine grained, brownish gray with greenish gray mottling and rare small patches of calcite. Sample HC-72
37'1/2"	3 1/2"	Light olive gray (5Y5/2) with pale olive mottling (10Y6/2) patches of calcite filling Tetradium in life position. Sample HC-73 Sample HC-73A
37'1 1/2"	1"	Moderate olive brown (5Y4/4) to grayish olive (10Y4/2) very fine grained argillaceous limestone appears to be laminated. Sample HC-74
38'2 1/2"	13"	Grayish olive (10Y4/2) very fine grained agrillaceous limestone with laminations that average 1/4 inch. Dark brown stains. Possibly mud cracked. Sample HC-74A
38'3 1/2"	1"	Wavy irregular bottom possibly current ripple marks, also large mud cracks, in light olive gray (5Y5/2) argillaceous limestone or dolomite with interlamina calcite patches about 1 to 3 mm. Possibly fossils present. Sample HC-75

Thickness Cum.	Interval	Description
38'6"	2 1/2"	Argillaceous limestone very similar to HC-75, HC-74, and HC-74A. Very weathered, breaks up into about 1 inch polygons porbably an indication of mud cracking. Sample HC-76
39'5"	11"	Olive gray (5Y4/1) with dark greenish gray mostly (5GY4/1), very fine grained with coarse patches and nodules of brownish black to olive black chert. Nearly the top 3 inches of this interval of limestone is replaced by chert with about one inch patches of limestone left unchanged. Brachiopods (Zygospira sp.) and branchiopod fragments along with other bivalves. Top of chert jointed (main joint strikes about N45E with small cross fractures, etc., striking NW). Sample HC-77 Sample HC-78
42'5"	36"	Covered, possible interval includes bentonite, some light greenish color in residium.
42'8 3/4"	3 3/4"	Very fine to fine grained, between dark greenish gray (5G4/1) and medium bluish gray (5B5/1). Some calcite patches and brownish black staining. Sample HC-79: All of unit and the unit above.
42'10 1/2"	1 3/4"	Mostly fine grained, medium dark gray with very fine grained material becoming more very fine grained toward the top. Top of bed mud crack polygons 3 to 4 inches wide. (Jointed about N45E) dark brownish black stains.
42'11 3/4"	1 1/4"	Dark greenish gray mixed with olive gray. Very fine grained with some fossil fragments. About 1 mm patches of calcite. Mud crack polygons about 2 to 3 inches across. Sample HC-80
43'4 1/2"	4 3/4"	Lower 3/4 inch olive gray, fine grained with light olive gray laminations. May be some intraclasts. Small about 2 mm calcite patches. Followed by fine to coarse grained with somewhat rounded intraclasts of the lithology at the bottom of the interval. Patches of white calcite filling brachiopods and orthocones and/or crinoid columnals. Some of the intraclasts at angles to bedding. Sample HC-81: Bottom 3/4". Sample HC-82
43'6 3/4"	2 1/4"	Argillaceous or dolomitic limestone very fine grained, light olive gray (5Y5/2) with brownish black stains, possibly laminated. Sample HC-83

Cum.	Thickness Interval	Description
43'10"	3 1/4"	Dark yellowish brown, very fine grained to fine grained argillaceous limestone matrix with fossil fragments mostly those of brachiopods with calcite fillings. Possible burrows on top. Sample HC-84: Bottom. Sample HC-85: Top
44'7 1/4"	9 1/4"	Argillaceous limestone laminated, close to moderate olive brown. Alternating with olive gray, very argillaceous limestone, some dark coarse fragments, may be fossils. Sample HC-86 Sample HC-87: About 3" from base, 1" thick.
44'8 1/4"	1"	Fine to coarse grained argillaceous limestone olive gray (5Y4/1). Sample HC-88
44'11 3/4"	3 1/2"	Olive gray becomes light olive gray at top, nodular thinly laminated, very fine grained argillaceous limestone. Looks mud cracked on weathered surface about 2 to 3 inch polygons. Coarse grained patches prominant near top. Possibly brachiopods filled with calcite. Sample HC-88 Sample HC-89: About 2" bed at top.
45'3 1/4"	3 1/2"	Olive gray to light olive gray argillaceous limestone. Very fine grained nodular to thin laminated with fine grained and coarse grained patches of calcite. Brachiopod fragments. Sample HC-90: Middle 3/4". Sample HC-91: Top.
45'7 1/4"	4"	Olive gray, very fine grained limestone (?) with laminations, seems to be weathered into large polygons. Sample HC-92: Bottom half.
46'2 3/4"	7 1/2"	Olive gray, very fine grained argillaceous limestone thin laminations look cross bedded in bottom 2 inches, similar to HC-92 lithology and weathering.
46'5"	2 1/4"	Olive gray, very fine grained limestone with coarse grained fossil hash in lenses. Sample HC-93 Sample HC-93A
46'9 1/2"	4 1/2"	Olive gray (5Y4/1) with darker about olive black laminations, very fine grained, breaks concoidally and weathers along concoidal surface. Three inches in interval similar to lithology below. Sample HC-94 Sample HC-95

Cum.	Thickness Interval	Description
47'1 1/2"	4"	Olive gray to darker olive black shaly limestone about 1/2 inch slabs.
47'9"	7 1/2"	Very similar to HC-95 concoidally breaking olive gray, very fine grained limestone. Sample HC-97
48'5 1/2"	8 1/2"	Olive gray to light olive gray, moderate brown mottling, thin laminations of very fine grained limestone with coarse grains near the top. Three to four inch mud crack polygons. Sample HC-98: Top of unit.
48'7 1/2"	2"	Olive gray, very fine grained limestone with laminations and birdseyes. Mud crack polygons 6 to 8 inches across. Sample HC-99
49'1 1/2"	5-6"	Shale, yellowish gray color (5Y7/2) thin laminations break up into 1/8 to 1/4 inch pieces with irregular surfaces. Deeply weathered. Sample HC-100: Grab sample.
49'7 3/4"	6 1/4"	Olive gray to light olive argillaceous limestone or dolomite with birdseyes, some interlamina. Some dark laminae near top. Sample HC-101: Bottom. Sample HC-101A: Top
49'10 3/4"	3"	Olive gray, coarse grained limestone with calcite patches (birdseyes) and very fine to fine grained matrix some very fine grained lenses appear to be deeply mud cracked on weathered surface. Sample HC-102: Includes part of unit above.

TOP OF CARTERS LIMESTONE, UPPER MEMBER

SUBSEQUENT UNITS LOWER PART OF HERMITAGE FORMATION

Cum.	Thickness Interval	Description
50'3/4:	2"	Fossil hash and rounded intraclasts (note very large intraclast on HC-102).

Cum.	Thickness Interval	Description
50'3 3/4"	3"	Dusky yellowish brown and lighter (fairly weathered) coarse grained limestone large fossils, bryozoans, brachiopods and crinoid columnals. Sample HC-103
50'5"	1 1/4"	Fine grained alternating dark and light layers near olive black then coarse grained, olive black to olive gray fossils with calcite filling bryozoans, brachiopods and crinoid columnals. Sample HC-104
51'7"	14"	Covered.
52'4"	9"	Coarse grained fossil hash, some layers dark (olive black) and lighter bands of fine grained. Lenses of larger fragments. Appears to be cross bedded. Sample HC-105
52'7"	3"	Grayish orange pink (5YR7/2) to pale brown (5YR5/2) fine to coarse grained, possibly large fossils brachiopods, etc. Sample HC-106
52'9 1/2"	2 1/2"	Coarse grained fossil hash. Sample HC-107
54'3 1/2"	18"	Very similar to lithology of HC-106. Sample HC-108

MCWILLIAMS CREEK SECTION

Mount Airy quadrangle, Tennessee 7.5 minute series, Topographic 104-NE (1946, Revisions 1966). The section is in the creek bed. The base is under the bridge where east valley road crosses McWilliams Creek and extends about 200 feet upstream to the east. (Tennessee Coordinates 380,100N., 2,207,850E. to 380,175N., 2,208,050E.)

UPPER PORTION OF CARTERS LIMESTONE, LOWER MEMBER

Cum.	Thickness Interval	Description
6 1/2"	6 1/2:	Dark yellowish brown (10YR4/2) to dusky yellowish brown (10YR2/2), very fine grained limestone with scattered concentrations of fossil fragments [brachiopods, ostracods (?), and crinoids (?)] with between pale yellowish brown (10YR6/2) and dusky yellowish brown (10YR2/2) weathers to moderate yellowish brown (10YR5/4) to grayish orange (10YR7/4) fine grained interconnected mottling patches (burrows?) mostly horizontal, some more or less vertical. Fossil tabulate coral (?) about 3 inches in diameter at base. Sample MC-1 Sample MC-1A
1'6"	11 1/2"	Same basic lithology as MC-1, irregular partings of brownish black (5YR2/1) appears to line mottled areas. Sample MC-2 Sample MC-3
2'6"	12"	Dark yellowish brown (10YR4/2) to dusky yellowish brown (10YR2/2), very fine to fine grained limestone with fine grained burrow mottling. Sample MC-4: Bottom 4".
3'2"	8"	Dark yellowish brown (10YR4/2) to dusky yellowish brown (10YR2/2) very fine grained with clear to white calcite filling fossils (brachiopods?). Horizontal irregular stringers (burrows) of fine grained material about same color as very fine grained. Probably represents burrow mottling. Dusky yellowish brown (10YR2/2) to brownish black (5YR2/1) material appears to line mottled areas. Sample MC-5: Bottom 4 1/2"
3'6"	4"	Same as Sample MC-4 with brownish black (5YR2/1) mottling in about the bottom 1 inch in thin (about 1/8 inch) stringers, also fossil fragments dispersed through matrix. Sample MC-6
5'	18"	Same lithology as Sample MC-1. Sample MC-7: Bottom 5".
5'2"	2"	Very fine to coarse grained fossil hash sorted into dark and light layers. Overall color is dusky yellowish brown (10YR4/2). Fossils appear to be brachiopod and crinoid fragments. Sample MC-8

Cum.	Thickness Interval	Description
5'5 1/2"	3 1/2"	Dark yellowish brown, very fine grained limestone with coarse grained layer about 1/2 inch above base (fossil fragments) and mottling is fine grained close to pale yellowish brown color. Scattered fossils and fragments. Sample MC-9
5'9 1/2"	4"	Dark yellowish brown, very fine grained limestone with fine grained mottling, stylolite-like structure vaguely associated with mottling. Fossil fragments of brachiopod and crinoids scattered. Sample MC-10
7'5 1/2"	20"	Dark yellowish brown (10YR4/2), very fine grained limestone with light olive gray, fine grained mottling. Stylolites associated with (?) mottling. About 1 inch from top very fine to coarse grained fossil fragments mostly brachiopods and crinoids, also round intraclasts. Sample MC-11: Top 6".
8'7 3/4"	14 1/4"	Dark yellowish brown (10YR4/2), very fine grained to coarse grained. Coarse grains concentrated in layers and are crinoid fragments, brachiopods and bryozoan. Fine grained mottling light olive gray to yellowish gray (5Y7/2) mottling mostly concentrated in very fine grained but also present in coarse concentrations. Noted coarse fragments of fossils in fine grained mottled areas. Sample MC-12: Bottom 2".
10'4 3/4"	21"	Yellowish gray (5Y7/2) to light olive gray (5Y5/2) fine grianed mottling with very fine grained dark yellowish brown (10YR4/2) to dusky yellowish brown (10YR2/2) now only 40 percent or so of the sample. Sample MC-14: Middle 4".
10'11 3/4"	7"	Alternation of coarse fossils and fragments (crinoid, brachiopods, gastropods, ostracods?) in very fine grained matrix about olive gray (5Y4/1) with fine grained yellowish gray (weathed) to about medium gray (N-5). Sample MC-15: Bottom 3".
11'2 1/4"	8"	Covered.
13'10 1/4"	24"	Dark yellowish gray, very fine grained limestone with fine grained mottling about medium gray (N-5). Local concentration of fossils and fragments mostly crinoid and brachiopods. Sample MC-17 Sample MC-18

Cum.	Thickness Interval	Description
14'9 1/4"	11"	Color close to dusky yellowish brown (10YR4/2) and olive gray (5Y4/1), very fine grained with fine grained mottling grayish to yellowish gray. Layer about 1/8 inch calcite filled or replaced brachiopods, Ostrados and bryozoans. Sample MC-19: Bottom 4 1/2".
15'1/4"	3"	Very fine to coarse grained, dark yellowish brown with patches of white calcite filling fossils and voids. Fragments of trilobites (?), brachiopods, and crinoids. Sample MC-20: Top 1 1/2".
15'10 1/4"	10"	Very fine grained, dark yellowish brown (10YR4/2) with fine grained, yellowish gray (5Y7/2) (weathered) to about medium gray (N-5) essentially horizontal with occasional fossils (brachiopod or ostracod) fragments and clear calcite filling fossil or irregular vugs. Sample MC-21: Bottom 3".
17' 1/4"	14"	Mostly covered, about the same as the interval below. Sample MC-22: Top 2".
17'6 1/4"	6"	Very fine grained to fine grained dark to dusky yellowish brown. The fine grains in darker layers also fine grained about dusky yellowish brown, thinner mottling from less than 1 mm to about 3 mm thick. Sample MC-23: All.
18'3/4"	6 1/2"	Mostly very fine to coarse grained, dark yellowish brown with the coarse constituents of fossils and fragments concentrated in patches (one about 1 1/2 inch across) gray fine grained mottling with black coating (organic?) between matrix and fine grained mottling. Sample MC-24: All.
18'7 3/4"	7"	Very fine grained to mostly coarse grained dark yellowish brown (10YR4/2) with some dark fragments. Mostly fossil hash of fine to coarse fragments at bottom. Size of grains less than 1 mm to about 2 mm maximum. Upper 1 inch consists of brachiopods and trilobite (?) fragments average about 5 mm long dimension in a very fine grained matrix. Fine grained mottling with dark boundaries at top. Sample MC-25: Top 3".
20'5 3/4"	22"	Very fine grained, dark yellowish brown (10YR4/2) with medium gray, fine grained mottling. Very fine to mostly coarse grained fossil fragments in about 1/2 inch layer. Sample MC-27 Sample MC-26

Cum.	Thickness Interval	Description
21'11 3/4"	18"	Very fine to fine grained mottled limestone, dark yellowish brown with dark yellowish brown to pale yellowish brown to medium gray fine grained mottling. Fossils present are bryozoans, look silicified, and some trilobite fragments. Top of unit is olive gray, very fine grained with about 1 mm spots and tubes (worm tubes?) of medium light gray color (N-6) with a band about 1/2 inch thick of medium light gray color at about the center of the sample. About 3/4 inch of olive black chert with olive gray spots and tubes. Sample MC-28: Bottom 2". Sample MC-29: Top 2 1/2".

TOP OF CARTERS LIMESTONE, LOWER MEMBER

SUBSEQUENT UNITS PART OF CARTERS LIMESTONE, UPPER MEMBER

Cum.	Thickness Interval	Description
25'3 3/4"	36-40"	Covered probably includes approximately 36 inches of bentonite and reworked bentonite.
25'4 3/4"	1"	Olive gray (5Y4/1), very fine to coarse grained (fossils?) filled with clear and white calcite (sample covered with argillaceous light olive gray, very fine grained material). Sample MC-30
25'8"	3 1/4"	Light olive to olive gray (5Y6/1/4/1), very fine to coarse grained, alternating coarse grained mostly brachiopods filled with calcite and fragments of other forms such as bryozoans, in a very fine to fine grained matrix. Sample MC-31
26'8"	12"	Olive gray, very fine to coarse grained with birdseyes (filling cracks??) and fossils that are mostly silicified. Evidence of mud cracks. Sample MC-33
27'2"	6"	Covered.
27'6"	4"	Medium light gray to medium gray mudstone with light olive gray laminae alternating with medium light to medium gray. Mud cracked, small polygons about 1 1/2 inch across. Sample MC-34

Cum.	Thickness Interval	Description
27'7 1/4:	1 1/4"	About same as unit below (Sample MC-34). Sample MC-35
27'11 1/4"	4"	Covered.
28'9 1/4"	10"	Olive gray, very fine grained (dense) limestone with calcite filling mud cracks (?) and isolated patches. Sample MC-36 Sample MC-36A
29'9 1/4"	12"	Covered.
30'1 1/4"	4"	Very fine grained, olive gray mudstone with abundant birdseyes of calcite mostly about 2 mm or so long, less than 1 mm wide, oriented horizontal, many microscopic suggesting laminations and/or dessication cracks, a few are vertical. Silty layers, medium light gray to yellowish gray (weathered). Mud cracks, some intraclasts and patches of fossil fragments. Sample MC-37
30'4"	2 3/4"	Light olive gray (5Y5/2), very fine grained to fine grained mudstone with light gray patches possibly horizontal and mostly vertical burrows, fine grained (?) fossil hash. Sample MC-38
30'8 3/4"	4 3/4"	Layers about 1/4 to 1/2 inch of silty, some thin laminations and mud cracks (?) light olive gray, alternating with olive gray birdseyes, very fine grained limestone. Sample MC-39 Sample MC-40
31'9 3/4"	13"	Covered.
31'11 3/4"	2"	Same lithology as unit below Samples MC-39 and MC-40. Sample MC-41 Sample MC-42
32'5 3/4"	6"	Olive gray, very fine grained mudstone with birdseyes of calcite concentrated along some laminations. Sample MC-43
33'5 3/4"	12"	Covered.
33'11 3/4"	6"	Alternation of layers about 1/4 inch thick of very fine grained, greenish gray (5GY6/1) and dark greenish gray (5GY4/1) with some pale olive (10Y6/2) fine grained (?) burrows, also grayish olive (10Y4/2) spots possibly transverse sections of burrows. Samples MC-44

Cum.	Thickness Interval	Description
34'2 3/4"	3"	Dark greenish gray (5GY4/1) with greenish gray mottling (look like worm tubes), laminated, mudstone (?) with prominant layer about 3/4 inch cross laminated with lens shaped and circular (?) intraclasts or mottling, some patches of calcite. Sample MC-45
34'6 1/2"	3 3/4"	Dark greenish gray to greenish gray with grayish red purple (5RP4/2) calcareous mudstone. Mud cracks, 1/2 to 1 inch polygons. Sample MC-46 Sample MC-47
34'9 1/2"	3"	Greenish gray and grayish red purple (5RP4/2) mudstone. Some laminations and mud cracks. Sample MC-48
34'11 1/2"	2"	Covered.
35'3 3/4"	4 1/4"	Bottom 1 inch is an irregular mudstone layer of greenish gray to olive gray and greenish red purple with birdseyes and flow sturctures in laminations. About 3" greenish gray and grayish red purple (5RP4/2) mudstone. Some laminations and mud cracks. Sample MC-49
35'9 3/4"	6"	Dark greenish gray very fine grained, laminated, mudstone with mud cracks. Patches to layers of gray (5Y4/1), very fine grained birdseyed limestone. Patch of angular intraclasts from dark greenish gray layers. Sample MC-50
36'1 1/4"	3 1/2"	Abundance of greenish gray (5GY6/1) subangular to rounded intraclasts in an olive gray, very fine grained matrix. Sample MC-51
36'7 1/4"	6"	Grayish olive (10Y4/2) to pale olive (10Y6/2), very fine to fine grained, mudstone with irregular partings. 1/4 inch layer of calcite filled fossils and fragments near bottom. Brachiopods observed. Bottom 3" covered. Sample MC-52
36'11"	3 3/4"	Olive gray (10Y4/2) laminated, very fine to fine grained mudstone followed by about 1 inch of olive gray, very fine to coarse grained mixed with dusky yellow green (5GY5/2) coarse material consists of brachiopods and ostracods (?) mostly disarticulated. Some branchiopods filled with sparry calcite (white) other areas may be gastropods filled with sparry calcite, some mudfilled. About 2 3/4 inches of dark greenish gray (5GY4/1) to grayish olive (10Y4/2), very fine grained to fine grained, laminated mudstone, some mottling possibly due to worms, etc. Sample MC-53

Thickness Cum.	Interval	Description
37'1/2"	1 1/2"	Dark greenish gray to olive gray, cross laminated, very fine to fine grained siltstone or calcareanite. Sample MC-54
37'3"	2 1/2"	Dark greenish gray (5GY4/1), very fine to fine grained mudstone. Sample MC-55
37'4 1/2"	1 1/2"	Dark greenish gray, very fine grained mudstone alternating with olive gray, very fine grained to fine grained mudstone. (Very argillaceous.) Sample MC-56
37'7 1/2"	3"	Covered.
37'9 1/2"	2"	Dark greenish gray, very fine grained laminated mudstone, alternating with thin laminae of olive gray, very fine grained. Occasional brachiopods and ostracods. Sample MC-57
37'11 1/2"	2"	Dark greenish gray to greenish gray, very fine grained limestone. Mud cracked, polygons from 1/2 inch to about 2 inches across. Also olive gray, very fine grained with birdseyes. Some coarse fossil fragments.
38'9 1/2"	10"	Covered.
38'11"	1 1/2"	Between greenish gray and dark greenish gray, very fine grained calcareous mudstone, irregular laminations. Sample MC-59
39'1/2"	1 1/2"	Same lithology as below (Sample MC-59), except occasional ostracod shells observed. Sample MC-60
39'9 1/2"	9"	Dark greenish gray, very fine grained calcareous mudstone with olive gray lenses and connecting thin (about 1 mm) stringers. Very fine grained matrix with birdseyes and fossils [brachiopods (?) filled with calcite] also occasional intraclasts in a dark greenish gray, very fine grained matrix. Highly mud cracked on surface of outcrop. Polygons about 2 inches across. Sample MC-61: Bottom 2".
40'4 1/2"	7"	Same type lithology as below. Mud cracks wider and larger, layers curve upward where mud cracked, more lenses of olive gray birdseyes and fossil fragments. Sample MC-62: Top 2".

Cum.	Thickness Interval	Description
40'5 1/2"	1"	Dark greenish gray (5GY4/1) very fine grained calcareous mudstone. Sample MC-63
40'6 1/2"	1"	About same as interval below (Sample MC-63). Weathers, yellowish gray to dusky yellow brown. Sample MC-64
40'9 1/2"	3"	Dark greenish gray (5GY4/1), very fine grained to fine grained calcareous mudstone with mud cracks and/or burrows. Sample MC-65 Sample MC-66
41'1 1/2"	4"	Covered.
41'5 1/2"	4"	Greenish gray to dark greenish gray mottled with olive gray concentrations and layers. Abundant fossil fragments, some mudfilled. Bryozoans (chert, olive black filling centers), gastropods, brachiopods, trilobite fragments, crinoid columnals, intraclasts (?). Pyrite present in small, less than 1 mm, crystals. Sample MC-67
41'9 1/2"	4"	More of same lithology as below (Sample MC-67), fossil fragments seem larger, bryozoans seem more plentiful. Sample MC-68
42'1/2"	3"	Fossil hash in olive gray, very fine grained matrix. Some scour and fill apparent. Pyrite present, also seems to be more silicified especially centers of bryozoans than interval directly below. Possibly rounded intraclasts. Large brachiopod about 3 cm across filled with white sparry calcite. Burrows possible. Sample MC-69
42'5"	4 1/2"	Greenish gray and olive gray, very fine to coarse grained limestone, similar to three units below (Samples MC-67, MC-68, MC-69). Most of this interval invaded by greenish black chert. Sample MC-70
46'11"	48-54"	Covered, interval probably contains about 36 inches of bentonite.
47'3"	4"	Greenish gray, very fine to fine grained laminated limestone with olive gray layer of very fine grained. Abundant 'birdseyes, also possibly vertical burrows from top of layers down. Some mudfilled, others calcite filled. Sample MC-71

Cum.	Thickness Interval	Description
48'4 1/4"	13 1/4"	Greenish gray very fine to coarse grained with olive gray patches. Abundant fossils in fine grained matrix, calcite patches filling fossils and voids. Pyrite in top 1 inch. Sample MC-72 Sample MC-73 Sample MC-74: Top 1".
48'5 3/4"	1 1/2"	Dark greenish gray, very fine grained with calcite birdseyes and fossil fragments. Also olive gray, very fine grained to fine grained, with pyrite and birdseyes. Sample MC-75
48'8"	2 1/4"	Greenish gray and olive gray laminated very fine grained mudstone, followed by olive gray, fine grained matrix with subrounded to subangular intraclasts and calcite filled brachiopod and other fossils. Sample MC-76
48'11"	3"	Between greenish gray and dark greenish gray, very fine grained layers and olive gray, very fine to fine grained layers which contain fossil hash of brachiopod fragments, etc. Well sorted near top. Sample MC-77
49'11"	12"	About same as below except some mud cracking or possibly vertical burrowing. Sample MC-78
50'1 1/4"	2 1/4"	Greenish gray to dark greenish gray, very fine grained mudstone with fossil fragments, ostracods and trilobites. Olive gray (5Y4/1), very fine to fine grained matrix with abundant sparry calcite filled fossils and birdseyes. Pyrite, some cross laminations, and intraclasts. Sample MC-79
50'2 3/4"	1 1/2"	Greenish to dark greenish gray, very fine grained mudstone with patches of fossil fragments. Sample MC-80
50'7 3/4"	5"	Dark greenish gray, very fine grained and olive gray, very fine grained with coarse fossils filled with mud and sparry calcite. Fragments of brachiopods, possibly gastropods, ostracods (?), etc. Intraclasts (?) of both lithologies or interfingering found in matrix of other. Some lamination towards top. Sample MC-81: Bottom 3".

Cum.	Thickness Interval	Description
50'8 1/4"	1/2"	Laminated, dark greenish gray and greenish gray, very fine grained alternating with coarse intraclasts and fossil fragments. Sample MC-82
51'8 1/4"	12"	Covered.
52'5 1/4"	9"	Dark greenish gray, greenish gray and olive gray laminated and mottled, very fine grained limestone which is somewhat intraclastic or cross laminated. Sample MC-83: Top 4".
52'9 1/4"	2 1/2-4"	Dark greenish to olive gray laminated very fine grained limestone with occasional sparry calcite patches that average about 1 mm across. Sample MC-84
53'5 1/4"	8"	Very fine grained to fine grained, greenish black to olive black laminated limestone (calcareanite), sparry calcite filling fossils (?). Sample MC-85
53'7 1/4"	2"	Very fine grained, dark greenish and olive gray birdseyes or fossils in abundance in this interval possibly some intraclasts. Sample MC-86
53'9 1/4"	2"	Dark greenish gray, very fine grained limestone, occasional patches of calcite, and olive gray, very fine to coarse grained with abundant clear calcite as birdseyes or fossil filling. Sample MC-87

TOP OF CARTERS LIMESTONE, UPPER MEMBER

SUBSEQUENT UNITS LOWER PART OF HERMITAGE FORMATION

Cum.	Thickness Interval	Description
54'1 1/2"	4 1/4"	Olive gray to olive black, very fine to coarse grained fossiliferous limestone, fossils include mudfilled brachiopod and ostracod valves, fragments of mat-like bryozoans which have been folded and refolded. Sample MC-89

Thickness Cum.	Interval	Description
54'6"	4 1/2"	Dark gray with light olive gray mottling, fine to coarse grained. Almost a sandstone (fossil hash). Wavy partings and concentrations of larger fragments in wavy layers. Sample MC-90
55'6"	12"	Covered.
55'8"	2"	Dark gray, very fine to fine grained calcareous sandstone, made up of fossil fragments. Sample MC-91
58'	28"	Covered.
58'3 1/4"	3 1/4"	Olive gray to brownish black coarse grained fossiliferous limestone with white and clear sparry calcite cement. Abundant bryozoans, brachiopod and ostracod fragments. Sample MC-93
58'10 3/4"	7 1/2"	Dark gray to brownish black, fine grained and very fine grained limestone. Brownish gray, coarse grained limestone with sparry calcite (white and clear) cement and fossil filling. Brachiopods and bryozoans abundant. Sample MC-94: Top 4".
60'3 1/4"	16 1/2"	Covered.
60'6 3/4"	3 1/2"	Olive black to olive gray, very fine to fine grained with olive gray and sparry calcite matrix. Coarse grained fossil hash, bryozoans, brachiopods, and crinoid columnals (?). Sample MC-95
61'3/4"	6"	Covered.
61'10 1/4"	9 1/2"	Very fine to fine grained matrix about olive to light olive gray with dark fossil fragments, about 2 mm across, randomly oriented, bryozoans abundant. Top part coarse grained brownish black to dark gray fossiliferous limestone with large sparry calcite filled brachiopods and clear and white sparry calcite cement. Sample MC-96: Bottom 3". Sample MC-97: Top 1 1/2".

APPENDIX B

APPENDIX B

SELECTED COMPOSITION ANALYSES OF THIN SECTIONS CHOSEN FOR DETAILED STUDY

This appendix is composed of summaries of selected point count analyses of lithologies amenable to this type analysis. All analyses are based on counts of 500 points per sample.

Lithologies not included in this appendix are 12, 13, and 17. Lithology 12 is not included because it is approximately 100 percent chert replaced which obscures original depositional texture. Lithology 13 is "bentonite", high in clay content, and impossible to thin section. Lithology 17 is not included because it is high in clay content and the samples have also been subjected to a high degree of weathering making them impossible to thin section.

TABLE BI

LITHOLOGY 1 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers						
	L-6	L-9 Lower	L-9 Upper	P-7	P-15	HC 3	HC 17
Micrite	60.6	65.4	10.2	66.0	48.4	50.8	47.4
Spar	4.0	4.4	43.6	1.0	4.6	----	6.6
Microspar	2.8	6.2	1.2	4.0	0.6	0.6	0.6
Intraclasts	0.2	----	31.8	----	11.6	----	2.0
Peloids	11.4	15.0	4.4	----	11.6	----	34.6
Algal debris	0.4	----	0.6	----	----	----	----
Molluscan debris	0.6	----	----	----	2.0	----	0.2
Trilobite debris	0.2	----	0.2	----	----	----	----
Echinoderm debris	0.4	1.0	3.0	0.6	9.0	----	4.0
Brachiopod valves	----	----	2.0	----	1.2	----	----
Bryozoan debris	----	----	0.6	----	1.6	----	----
Oncolite	----	----	0.2	----	----	----	----
Coral	----	----	----	----	1.0	----	----
Unidentified fossils	1.8	1.2	2.2	----	----	----	----
Stylolites (Pressure-solution)	----	----	----	----	0.2	----	0.6
Dolomite rhombs	17.6	6.8	----	28.4	8.2	48.6	4.0
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE BII

LITHOLOGY 2 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers			
	L-12	L-19	P-22A	HC 30
Micrite	20.2	12,4	2.8	18.8
Spar	40.4	16.2	23.0	45.8
Peloids	23.2	20.6	61.0	----
Pelecypod debris	2.8	0.8	11.4	0.6
Trilobite debris	3.8	----	0.2	----
Gastropod debris	4.0	29.8	1.6	5.2
Echinoderm debris	1.2	1.2	----	3.0
Bryozoans	4.0	2.4	----	----
Brachiopods	----	1.6	----	----
Unidentified fossil debris	----	12.6	----	26.4
Intraclasts	----	1.0	----	----
Dolomite rhombs	----	1.4	----	----
Stylolites (Pressure-solution)	0.4	----	----	0.2
Totals	100.0	100.0	100.0	100.0

TABLE BIII

LITHOLOGY 3 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituents	Sample Numbers					
	L-25	L-29	P-28	P-29	HC 40	HC 43
Micrite (possible peloids fossil fragments)[a]	90.8	90.4	86.0	88.0	92.0	80.2
Spar	9.2	9.6	14.0	12.0	8.0	15.8
Peloids?	----	----	----	----	----	3.6
Fossil fragments?	----	----	----	----	----	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a]Micrite may be 0 percent to 100 percent peloids or fossil fragments in 30 to 50 μ.

TABLE BIV

LITHOLOGY 4 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers			
	HC42	L28	P31	L30
Micrite	4.4	13.2	6.0	5.6
Spar	20.6	26.2	10.2	19.8
Intraclasts	59.4	47.0	76.4	52.4
Peloids	14.4	4.4	6.2	15.4
Brachiopod fragments	1.2	1.2	----	1.2
Echinoderm debris	----	0.6	----	1.4
Unidentified fossil fragments	----	7.4	1.2	1.2
Dolomite rhombs	----	----	----	3.0
Total	100.0	100.0	100.0	100.0

TABLE BV

LITHOLOGY 5 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers					
	L-37	L-42	P-40	P-42	HC 49	HC 51
Micrite	82.8	30.6	31.3	----	28.2	32.8
Spar	3.8	8.8	12.0	14.4	15.6	8.0
Peloids	----	45.0	42.3	42.0	33.0	42.8
Intraclasts	----	----	----	23.6	----	----[a]
Dolomite rhombs	13.4	15.6	14.4	20.0	23.2	16.4
Totals	100.0	100.0	100.0	100.0	100.0	100.0

[a]Intraclasts possible in other parts of slide.

TABLE BVI

LITHOLOGY 6 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers		
	L46B	P49	P-50
Micrite	59.2	7.6	9.2
Spar	14.8	17.2	16.4
Peloids	12.6	59.4	53.8
Dolomite rhombs	13.4	15.8	20.6
Totals	100.0	100.0	100.0

TABLE BVII

LITHOLOGY 7 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Number				
	L-53	P-54	P-59	HC 54	HC 56
Micrite	28.0	51.8	22.2	28.2	53.6
Spar	27.8	13.8	15.8	32.4	17.0
Peloids	33.6	28.4	51.6	32.8	25.8
Intraclasts	1.8	----	----	----	----
Trilobite debris	4.2	3.0	7.6	4.0	----
Brachiopod Valves	0.2	----	0.4	0.2	----
Echinoderm debris	2.8	2.4	0.2	0.8	0.2
Bryozoan debris	----	0.6	1.6	----	----
Unidentified fossil debris	1.6	----	0.6	1.0	1.8
Dolomite rhombs	----	----	----	0.6	1.6
Totals	100.0	100.0	100.0	100.0	100.0

TABLE BVIII

LITHOLOGY 8 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers					
	L59A	L60	P63	P67	HC70	HC73A
Micrite	21.2	33.2	23.2	58.2	66.8	75.8
Spar	48.4	34.0	33.6	27.2	19.0	16.2
Peloids	17.8	22.8	37.8	12.8	0.4	4.4
Intraclasts	----	----	0.6	----	----	----
Tetradium	9.6	2.6	0.2	----	11.2	3.6
Brachiopod valves	0.8	1.6	----	----	1.0	----
Echinoderm debris	0.2	2.2	1.8	0.6	0.8	----
Trilobite debris	1.0	0.4	0.8	0.4	----	----
Bryozoan debris	0.6	1.2	0.4	----	----	----
Algae?	----	----	0.4	----	----	----
Ostracods	----	----	----	0.2	0.4	----
Unidentified fossils	0.4	1.8	1.0	0.6	----	----
Dolomite rhombs	----	0.2	0.2	----	----	----
Stylolites and other pressure solution	----	----	----	----	0.4	----
Totals	100.0	100.0	100.0	100.0	100.0	100.0

TABLE BIX

LITHOLOGY 9 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituents	Sample Numbers					
	L-65	L-67	P-78	P-83	HC 77	HC 89
Micrite	77.6	71.4	83.6	82.0	48.4	76.2
Spar	10.6	16.2	3.4	2.2	16.2	11.0
Peloids	1.6	5.6	1.0	0.6	0.8	5.8
Echinoderm debris	3.8	0.4	8.2	6.4	8.3	3.2
Brachiopod valves	0.6	1.2	0.6	0.8	3.6	0.2
Trilobite debris	0.6	2.4	----	1.0	1.0	0.6
Molluscan debris	----	0.8	----	----	0.6	0.4
Coral	----	----	0.2	----	4.4	----
Bryozoan	----	----	----	----	3.4	----
Unidentified fossil debris	5.0	2.0	3.0	7.0	8.0	2.6
Quartz grains	0.2	----	----	----	----	----
Silica replacement	----	----	----	----	4.8	----
Total	100.0	100.0	100.0	100.0	100.0	100.0

TABLE BX

LITHOLOGY 10 ANALYSIS (VOLUME PERCENT OF CONSTITUENTS)

Constituent	Sample Numbers						
	(10A) L74	(10A) L75	(10A) P-89	(10A) P-91	(10A) HC105	(10B) P86	(10B) P88A
Micrite	3.0	12.6	33.6	----	21.0	52.8	10.8
Spar	65.2	46.2	6.2	51.2	29.8	1.2	15.2
Microspar	----	3.4	0.2	----	----	----	1.2
Intraclasts	0.2	----	----	----	----	----	----
Peloids	----	3.6	----	1.0	----	----	----
Brachiopod valves	2.8	5.0	7.0	9.4	7.0	3.2	11.6
Echinoderm debris	11.4	14.4	12.8	32.6	5.6	42.4	54.8
Coral	----	----	----	2.0	----	----	----
Trilobite debris	0.6	1.0	0.6	----	----	----	0.4
Bryozoan debris	0.8	6.8	24.2	----	3.8	----	4.4
Molluscan debris	0.2	----	----	----	----	----	----
Arthropod debris	----	----	----	0.8	----	----	----
Unidentified fossil debris	7.8	6.4	5.8	3.0	----	----	0.8
Dolomite rhombs	----	0.2	----	----	----	0.4	----
Dolomite replacing echinoderm plates	8.0	----	9.6	----	30.4	----	----
Opaque grains	----	----	----	----	0.8	----	0.8
Silica replaced limestone	----	----	----	----	1.6	----	----
Stylolites (Pressure-solution)	----	0.4	----	----	----	----	----
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE BXI

MISCELLANEOUS LITHOLOGIES ANALYSIS
(VOLUME PERCENT OF CONSTITUENTS)
LITHOLOGIES 11, 14, 15, 16

Constituent	Sample Numbers (Lithology)				
	(11) HC 15	(14) HC 59	(15) P32	(15) HC 46	(16) HC 75
Micrite	----	4.8	57.4	34.8	7.2
Spar	28.8	11.0	5.2	5.0	36.6
Microspar	----	----	1.2	3.2	----
Intraclasts	3.0	17.0	----	----	----
Peloids	----	66.2	----	----	54.4
Brachiopod valves	----	0.4	----	----	1.8
Echinoderm debris	45.4	0.2	----	----	----
Bryozoan/Coral debris	12.6	----	----	----	----
Molluscan debris	----	0.4	----	----	----
Unidentified fossil debris	10.2	----	----	0.4	----
Dolomite rhombs	----	----	34.6	56.6	----
Solution-pressure	----	----	1.6	----	----
Total	100.0	100.0	100.0	100.0	100.0

VITA

Ernest Wilson Blythe Jr. was born in Old Hictory, Tennessee on June 27, 1930. He attended DuPont Elementary School and graduated from DuPont High School in 1949. After a year of working with the E. I. DuPont Company he entered Tennessee Polytechnic Institute and received a Bachelor of Science Degree in Industrial Management in 1954.

From October 1954 to September 1956 was spent in the U.S. Army (most of the time attached to the U.S. Air Force in Germany).

The following years, from 1956 to 1964, were spent in management training and supervisory work for the Installation Division of the Western Electric Company.

In September 1964 he entered the University of Tennessee as a special student and took undergraduate courses in geology. The following year, 1965, he received a teaching assistantship and the Socony-Mobil Scholarship Award. He received a Master of Science Degree in 1967, while already pursuing a Doctor of Philosophy Degree. In 1969 he accepted a position as Assistant Professor of Geology at the University of Tennessee-Martin, where he is presently employed. He is a charter member of the Gamma Gamma Chapter of Sigma Gamma Epsilon, a member of Sigma XI, the National Association of Geology Teachers, and Geological Society of America. In June 1974 he received a Doctor of Philosophy Degree with a Major in Geology and a minor in Geography.